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ABSTRACT

The 54 conference papers and abstracts on the possible role of computers in the world of education in the Republic of South Africa which are presented in this volume are published under the sections and in the order in which they appeared on the congress program. The names of the sections and the number of presentations in each are as follows: (1) general perspectives, 16; (2) computer-based education in industry, 4; (3) computer-based education in schools, 7; (4) computer-based education at the tertiary level and in schools, 5; (5) computer-based education at the tertiary level, 10; (6) computers in language teaching, 5; and (7) papers received too late for classification, 7. Specific topics discussed include administration of computer-based education, computer-managed instruction, microcomputer applications and studies, cost effectiveness, teacher training, authoring techniques, networks, computer-assisted testing, and curriculum development, as well as applications in specific subject areas. Some papers include references and an author index is provided. (LMM)

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Proceedings of the South African Congress on
Verrigtinge van die Suid-Afrikaanse Kongres oor

Computers in Education Rekenaars in die Onderrig

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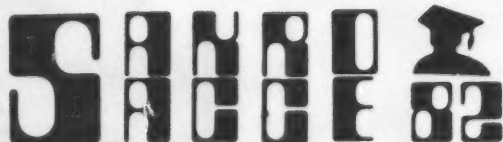
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April 1982

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Voorwoord

In die verslag van die Hoofkomitee van die RGN-onderzoek na die Onderwys wat in Julie 1981 gepubliseer is, word aanbeveel:

"Dat onderwystegnologie uit 'n beleidsoogpunt aanvaar moet word as 'n fundamentele faktor in die beplanning, ontwikkeling en implementering van die onderwysvoorsiening op alle vlakke, sowel in die formele as nie-formele sektore." (p. 171) en

"Dat aandag onmiddellik geskenk moet word aan die ingebruikneming van die rekenaar in onderwys." (p. 172)

Onder 5.7 Prioriteitsaanbevelings staan op p. 219:

"In die besonder moet aksienavorsing met betrekking tot rekenaar-ondersteunde onderrig en die inskakeling van die poskantoor en die SAUK op 'n samewerkingsbasis prioriteit ontvang." (5.7.3(b))

In Mei 1981 is onder die vleuels van die Buro vir Universiteitsonderwys van die Universiteit van Stellenbosch 'n begin gemaak met die reëlins vir die Suid-Afrikaanse Kongres oor Rekenaars in die Onderrig. Die hoofdoel met SAKRO 82 is om groter helderheid te verkry oor die rol wat die rekenaar in die komplekse en veranderende onderwyssituasie in die Republiek van Suid-Afrika kan speel. SAKRO 82 se organiseerders hoop dat die referate wat in hierdie kongrespublikasie opgeneem is, mag bydra tot spoedige en oordeelkundige besluitneming oor die wyer implementering van rekenaars in die onderwys.

Die referate word geplaas in die afdelings en volgorde waarin hulle in die Kongresprogram verskyn. Nóg aan die referate nóg aan die opsommings is enige redaksionele wysigings aangebring. Die feit dat 'n groot aantal referate betyds en in die verlangde formaat uitgelewer is, het die redaksionele werk aansienlik vergemaklik. Daar was geen tyd vir die oortik van referate nie. Referate waarvan slegs die opsommings in afdelings 1-6 verskyn is nie betyds deur die Kongressekretariaat ontvang nie. (Vide afdeling 7.)

Die redakteur betuig waardering teenoor mnr. John Blanckenberg, Reg Dodds en Jan Evertse, lede van die Program- en Redaksiekomitee, vir hulle hulp met die voorbereiding van hierdie bundel.

Dawid H van der Vyver.

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Preface

The Report of the Head Committee of the H.S.R.C. Investigation into Education, published in July 1981, recommends:

"That as a policy decision educational technology be accepted as a fundamental factor in the planning, development and implementation of educational provision at all levels, both in the formal and non-formal sector." (p. 171) and

"That immediate attention be given to the introduction of the computer in education." (p. 171)

Furthermore, under 5.7 Recommendations on Priorities one finds:

"Action research on computer-assisted instruction and the involvement of the Post Office and the SABC should be given priority." (5.7.3(b))

In May 1981 a start was made on the arrangements for the South African Congress on Computers in Education, under the auspices of the Bureau for University Education of the University of Stellenbosch. The main object of SACCE 82 is to obtain greater clarity on the possible role which computers may play in the complex and changing world of education in the Republic of South Africa. The organisers of SACCE 82 hope that the papers which have been gathered in this congress publication may contribute to rapid and judicious decision making on the wider implementation of computers in education.

The papers (and abstracts) are published under the sections and in the order they appear on the Congress programme. Neither the papers nor the abstracts were edited. The fact that a large number of the papers were received in good time, and in the required format, made the editorial work considerably easier. There was no time to retype any of the papers. Those papers which appear in summary form only under sections 1-6 did not reach the Congress Secretariat in time. (Vide section 7.)

The editor wishes to express his appreciation towards John Blanckenberg, Reg Dodds and Jan Evertse, members of the Programme and Editorial Committee, for their assistance in preparing this volume.

Dawid H van der Vyver

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COMPUTER-BASED EDUCATION: WHERE ARE WE HEADING?

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ABSTRACT

The University of Illinois has been developing large scale computer-based education systems over the past twenty years. The present PLATO system has over 1 200 terminals located at over 200 separate locations. Over 10 million terminal hours have been logged utilizing thousands of hours of lesson material. Based on experience and measured data in developing these systems, an attempt is made to forecast where CBE is heading. Various system configurations are proposed and the advantages of each discussed.

Computer-based Education: Where Are We Heading?

INTRODUCTION

There is no doubt that computer technology has changed quickly and drastically over the past 20 years. The advent of a microprocessor on a chip and inexpensive solid state memory has provided the impetus for a whole new industry of personal computers. How will this new technology affect computer-based education (CBE) and what additional problems remain to be solved?

In descriptive terms the CBE goal can be stated as the provision of effective lesson material that produces guaranteed educational results. The lesson must be delivered at low cost and at a time and place convenient for the student.

How does one convert this descriptive statement into an operational statement of system needs? What data rates are necessary between various parts of the system? What display functions are required? What kind of software programs will promote the production of effective courseware?

This paper will attempt to answer some of these questions by drawing on the data and experience obtained by developing and operating a large CBE system for the past 20 years.

Although no attempt will be made here to discuss how to create good courseware, an attempt will be made to describe the hardware and software parameters necessary for the production and use of effective courseware.

HISTORY

In order to understand the way that new technology might impact on present CBE, it is instructive to examine the past to see what forces and barriers have impacted on CBE developments.

Although transistors were available in the late 1950's, almost all of the useful computers were constructed with vacuum tubes and utilized slow and expensive Williams Tube CRT memory devices. Typical add times were 20 microseconds and multiply times were 500 microseconds. High speed memory size was 16k to 32k bytes, and rotating magnetic drums were used to augment the high speed memory.[1] Although the computer itself filled a large room, its processing power and memory capacity was approximately the same as today's desk top personal computers.

Typically only one or two displays would be attached to these computers and keyboards were individually built using microswitches.[2] CBE projects were forced to limit their scope of activities to match the computer's capability. Examples of these early CBE projects were stenotyping, elementary mathematics, and computer programming.

During the 1960's and early 1970's computers became faster and contained more high speed memory. Discrete solid state circuitry then improved reliability and reduced the cost. To further lower the cost it was desirable to share the computer among several users. Measurement of interaction rates between the user and the computer indicated that for interactive programs the average number of keys pushed per second and the computer usage of instructions per second were independent of the type of user and the material being presented.[3] For example, in drill and practice programs the answers are short, require little processing, but occur frequently. In science programs which require algebraic responses, the answers are longer and require more processing, but occur less frequently. The average key rate and processing power in each case is about the same. Based on these data, the increased power first, 12-24 terminals were attached, but by 1970 over 1000 graphic terminals were sharing the same computer system.

As the system expanded from a few terminals to many terminals, several important events occurred. First, the peak-to-average computer power for each user was increased. Although the average computer use per terminal remained small, the ability to momentarily utilize large amounts of computer power and memory permitted sophisticated answer judging within reasonable response times.[4,5,6] Second, the system characteristics evolved with the help of many users who by using the system could contribute comments and suggestions concerning hardware and software changes.[7] And finally, software and application packages were developed which required the shared efforts of several people working at different locations on the same program. Thus, the large system approach created a need for large software developments, but it also provided the means for implementing these changes.

Figure 1 provides some idea of the distribution of the computer code used in a large system such as the PLATO system. The amount of code written for a given purpose is represented by the area in the corresponding circular ring. As can be seen, the 5000 lines of code in the terminal is almost insignificant as compared to the 500,000 lines of code used to support the entire system or the 40 million lines of code needed for the available courseware. [8]

The communication capacity needs between the computer and an attached terminal has also changed drastically. Originally, most graphic terminals were supported from a centrally located memory such as disk storage or analog devices such as storage tubes. In order to support a flicker free video display, data had to be transmitted to the terminal at video rates. Such a wide band communication channel is acceptable as long as the terminals are located in close proximity to the memory supporting the display. However, as the system grew the terminals became more widely distributed, and the communication costs to provide a video channel to each terminal became prohibitively expensive.

This problem was solved in the PLATO IV system by moving the display generation to the terminal and developing a display with inherent memory.[9] By locating the display memory at the terminal the data rate to the terminal can be reduced from over 10 million bits per second to 1200 bits per second. This flat panel display is digitally addressable, can be written or erased dot by dot and is transparent, thus allowing superimposed rear slide projection. In addition, it provided a high quality flicker free display of excellent contrast and sharpness. Later solid state memory became sufficiently inexpensive to locally store the picture for a CRT display.

Even with these developments the cost of a long distance telephone line per terminal can be prohibitively expensive. Several other techniques were employed to further reduce communication costs. First, new modems were developed that allowed 9600 bits per second to be transmitted over an ordinary phone line. In addition, multiplexers were utilized which required the average transmission rate of only 400 bits per second per terminal instead of using 1200 bits per second per terminal. Consequently, over 16 terminals can now be supported with a single telephone line instead of using an entire video channel to support a single terminal.

But, hardware development is not the only important change to take place over the past 20 years. System software has also improved greatly. Originally, programs were written in machine language or assembly code, a difficult and tedious task. Then higher order languages, such as FORTRAN and BASIC, were developed which made computational programming easier. During the 1960's, special user languages for CBE, such as IBM's COURSEWRITER or PLATO's TUTOR [10] were written.

When microprocessors first appeared, the computer programming was again done in machine language. However, as memory became less expensive and the power of the microprocessor increased, higher order languages such as PASCAL and BASIC became available on personal computers. Recently, special CBE languages are appearing for microprocessor terminals.

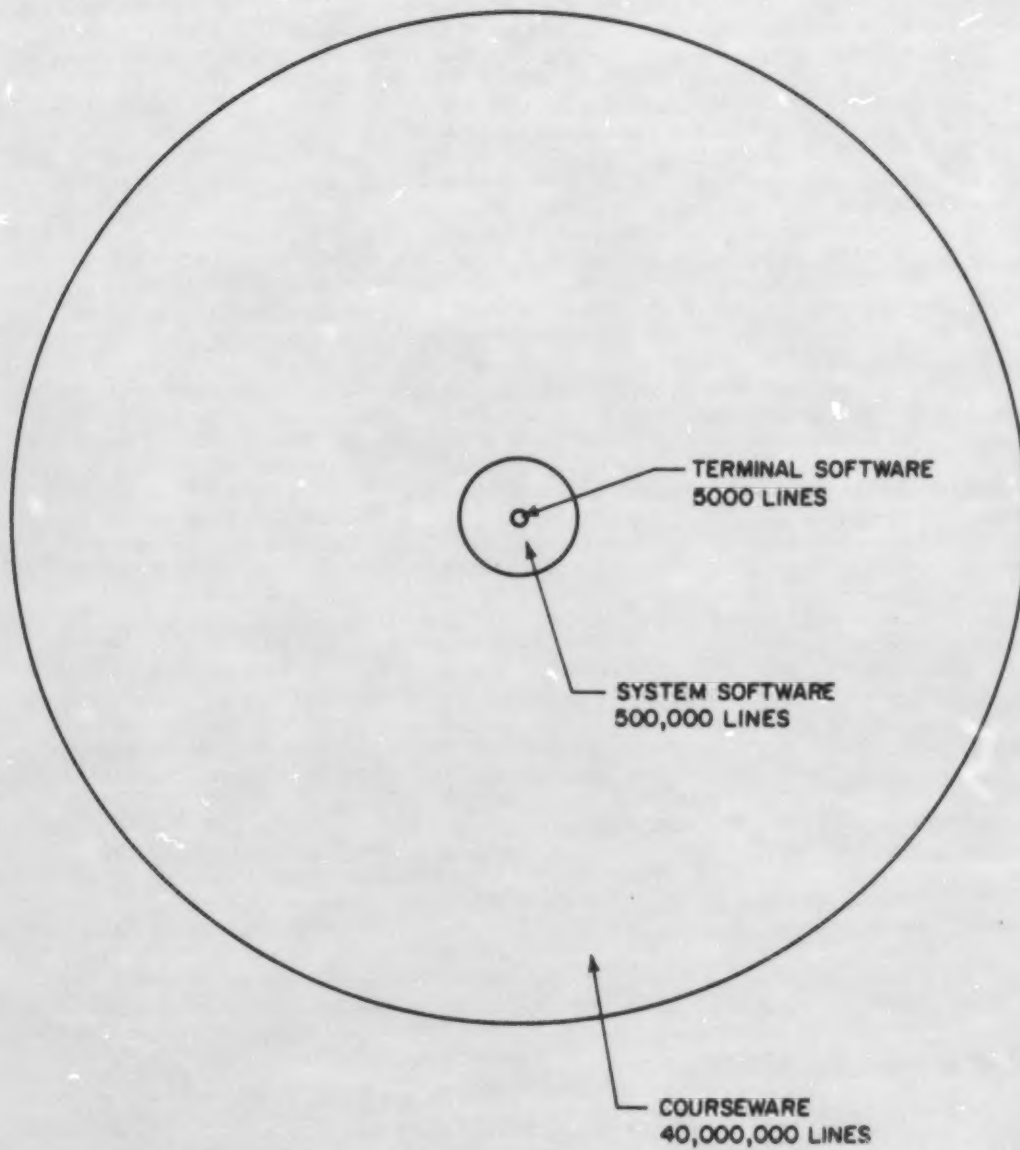


Figure 1: The annular areas shown in the figure illustrate the vast differences in computer code stored in different parts of the system.

PRESENT STATUS

Where do we stand today? Modern technology has made computer power inexpensive for both large central computers, as well as for small personal computers. This increase in microprocessor power and decrease in cost is likely to continue.

However, all is not perfect with the existing personal computer terminals. Most existing microprocessor terminals utilize a television (TV) quality display. Although this is adequate for computer programming, it is not satisfactory for effective CBE. Not only is the quality of display inadequate for CBE, but there is a great disparity in various display specifications. Some have graphics, others do not. Some have touch input devices, some do not. It is relatively easy to convert lesson material for execution by different processors. Some differences such as color can be substituted for by various shadings, and then replaced by color when high resolution color becomes available. However, size differences and display quality, such as resolution, make lesson conversion extremely difficult. Unfortunately, the most valuable and expensive part of a CBE system, the courseware, can easily be rendered useless by changes in the terminal display.

New communication technologies appear to offer several possible solutions for interconnecting the terminals. Two way cable systems already exist in many cities. New cable systems will have over 100 channels with most channels transmitting data instead of TV pictures. In the U.S. low power TV transmitters have been licensed to send data within a 30 mile radius. Common carriers are now planning channels that will bring a capacity of 64k bits per second into each home.

POSSIBLE SYSTEMS

What are some possible system configurations based on communication needs? Figure 2 is a table designed to show the communication requirements for various system configurations. The table illustrates the relationship between data transmission needs and the location of the computer processing and support memory. These data have been obtained from various studies conducted with PLATO systems.

Ignoring for the moment many of the system requirements needed to support the activities of a variety of users, we will now consider some of the possible system configurations. The simplest, least expensive, and most available CBE system today, is the stand alone terminal. It's communication to the outside world is usually limited, although some external interaction is possible to query data banks, leave messages, and exchange programs. This interaction usually takes place over dialup telephone lines. For reasons discussed later, a permanently isolated terminal has a distinct disadvantage. Usually, in a microprocessor terminal, the entire program must fit in the computer memory. Swapping pieces of the program between the memory and the attached floppy disk is not very satisfactory because of the long interruption incurred during the swapping time. Nevertheless, in some cases the computer program can be written within the computer memory size. In such cases, like games or small calculational programs, the stand alone computer terminal can be effective.[11] Eventually, it might be possible to provide each terminal with unlimited memory and computer power.

To help alleviate the swapping time problem several terminals can be connected to a mini-computer which has high speed memory. One of the functions of the mini-computer is to manage the swapping of program pieces to the terminals. However, this swapping can be done quickly since it does not depend on a mechanical disk drive. The program is then executed in the terminal, so that the computational load on the mini-computer is very small. The mini-

Item	Average Data Rate Bits/Sec	Peak Data Rate Bits/Sec	Display Processing and Memory Bytes
Keyset or Touch Input	10-20 (Return Channel)	300	Small
Formatted Output	400	1200	Circle-Line Character Generators Display Bit Map (32k)
Select Image Every 10 Sec	2	50	Entire Set of Pictures
Send Image Every 10 Sec	100k	100k	100k for Storing Image
Select Audio Every 10 Sec	4	100	All Audio Message
Synthesized Audio	100	1200	Phonemes and Vocal Track Model
Support Flicker Free Picture	2×10^7	2×10^7	None
Control Video Disk	30	1200	Video Disk
Synthesized Music	320	1200	Music Sound Synthesizing
Send Complete Lesson Every 10 Min	1000	80000	64k
Support Lesson Unit at a Time	10k	300k	16k

Figure 2: This table illustrates the ability to exchange bandwidth between different parts of the system for processing and memory.

computer also allows the sharing of its memory by many terminals so that the amount of memory required can be averaged. As can be seen from Figure 2 each terminal will require on the average 10k bits per second, and a peak rate of 300k bits per second. A two million bits per second channel will support over 100 terminals. Usually, this will require the terminals to be located fairly close together, and this approach is referred to as a cluster system. Several cluster systems can also be connected together to a large central system by an ordinary telephone line.

Another system configuration uses the terminal computer to generate the displays and leaves the execution of the lesson code for the central computer. In this configuration we have the lowest peak and average transmission rates to the terminal. Such a system is advantageous if either a large number of isolated terminals must be connected together or, if a single wide band channel such as cable TV is used to support a very large number of terminals (8000 per channel).

Finally, if data transmission rates become so large and inexpensive as to provide a separate video channel into every home, then even the display generation could be relocated at the central computing source, thus allowing the terminals to be simple and reliable.

SOFTWARE CONSIDERATIONS

In choosing a system design, one must also consider the system software. Up to now we have ignored the importance of having flexible and humane oriented software that will allow even a naive user to make full use of the computer.

What are some of the software considerations that the users have requested? Figure 3 is a table listing some of the important software functions for CBE. Some of these items such as editing are needed only for authoring. Others such as intercommunication are needed when the system has users physically separated from each other by large distances. Some features such as recordkeeping seem almost imperative for instruction unless the function is replaced by additional human labor.

One would like to provide all of the services as needed and still have an inexpensive system. Let us now consider in more detail two of the above options, which are now in use or under development at the University of Illinois.

The central system approach has been the major thrust of the PLATO program. This present system is the result of over 20 years of effort incorporating the experience and suggestions of many users. The functions available within the system make the system work within the naive environment. Thousands of authors create lessons on the system. Instructors can put together curriculum and manage large numbers of students. Students use the system for credited instruction and millions of contact hours have been logged. Then what problems remain? Two types of problems with the present system must be resolved for widespread use; those of cost and reliability. Since new computers are reliable and inexpensive, the communication channel cost and reliability remain the major problems.

Where two way cable TV exists these problems can be overcome. Recently we have been experimenting with techniques that will permit 8000 simultaneous users on a single forward and a single reverse TV channel. Each user can interact just as he now does with the PLATO system, unlike the existing TV polled systems which allow an interaction only every few seconds. In order to support the maximum number of users on a cable system most terminals would run their programs at the central computer, but a few could have their programs loaded to their terminals for execution. The central computer may in fact be several separate computers, but central execution of the program is necessary to reduce average bandwidth per terminal. The advantage of this approach is that we know

System Functions (500k Lines of Code)

User Type		
Author	Instructors	Students
Text Editors	Student Registration	Delivery of Lesson Material
Display Editors	Curriculum Generation from Lesson Catalog	Performance Grading and Progress Reports
Database Editors	Criteria for Student Progression to Next Lesson	System Wide Data Gathering for Educational Studies
Compilers/Interpreters	Keep Track of Student Progress	Communication with Instructor Through Notesfiles or On-Line
CBE Language Documentation and Debugging Aids	Schedule Terminal Use	Sophisticated Answer Processing Routines
On-Line Authoring Instruction	Communication with Other Users	Student Able to Compare His Progress to Other Students Without Security Violation
On-Line Access to Consultants	Performance Comparison Between Classes Without Violation of Security	
Data Gathering and Feedback		
Special CBE Language for Naive Authors		
Courseware Security		

Figure 3: A list of required system software functions is shown here for each of the three types of users.

how to make such systems work and it apparently meets the user's needs.

The second approach is a mixture of stand alone, cluster, and central system. The majority of the programs in such a system could be executed in the terminal. If a terminal had to be isolated, the program would run in conjunction with a floppy disk. When possible the cluster computer would supply the programs to the terminal. The cluster computer can be connected to a central system. Thus, when necessary, a few terminals can use the central system for running programs not available at the cluster and for storing and retrieving centrally collected data. In addition, the central computer can connect many clusters together for inter-cluster communication. The net result is to have a system with the PLATO system capability, but one that would fail more softly when communication to the central system fails. Also, many more terminals can share the main central system and a single telephone line will support the central computer communication needs of over 100 users.

FUTURE

Having looked at some of the past CBE developments and present user requirements, I will now make some predictions about the future.

In my opinion, future sales of personal home computers will continue to expand even though the software and human interface leave much to be desired. If one has a very small budget the choice is either a small personal computer or none at all. For some who are interested in computer programming the result will be satisfactory. Dialup networks will develop to provide message exchanges, access to data bases, and some computer program exchange. Incompatibility in the various displays will limit the type of interchanges possible.

However, in a few years, a system approach providing effective computer services for all types of educational services will occur. Terminals with adequate and compatible requirements will be specified. Courseware and application packages will be written with the expectation of being useful for several years. Excellent interactive computer services of all kinds will become available to the naive computer users.

Computer power will be distributed with some programs being executed in the terminals and the central computer simultaneously. It is likely that many of the programs will be executed in an interpretive mode so that the code produced by the author can be easily transferred to any computer or terminal.

Not much discussion has been given to peripheral devices such as speech synthesizers or video disks. These devices will certainly affect the pedagogy of good courseware, but as can be seen from the data in Figure 2, the demand on the system performance is minimal. Nevertheless, it is interesting to speculate on the future of some of these devices.

Voice output and superimposed slides have been found to be highly desirable at about 20% of the terminals. Usually the vocal output cannot be associated with a particular slide image. Turn around times of even a few days for producing slide images is sufficiently irritating to authors to limit their use to only when absolutely necessary. These experiences cause one to wonder about the future of video disks for CBE.

One can expect voice synthesizers to become inexpensive with a quality to rival that of recorded speech. Music synthesizers will also be of high quality and inexpensive.

In the near future new central memory devices will provide huge storage and data retrieval capability. Thus, it becomes conceivable to think in terms of storing the entire written content of several million journals and content searching the entire memory in less than a second. Imagine the impact on education and research with such a service available in every home and school!

CONCLUSION

The Achilles' heel of present mass marketed personal terminals for CBE consists of at least two serious problems. The first problem is to provide an adequate display which is sufficient to meet the requirements of a variety of educational uses, and thus guarantee that the large amount of effort and cost placed in developing courseware will not be made futile by continuous changes in displays.

The second problem is to provide a system approach which will make it easy for authors, teachers, and students to interact in producing excellent lesson materials. Such interactions require users to easily share ideas and common resources even though the users may be located at remote distances from each other.

Because of the importance of attacking and resolving these problems properly and because of the potential enormous market for CBE, these problems will be solved by large computer and telecommunication companies. In my opinion, computer-based education will have a bright and prosperous future.

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THE MANY FACES OF INSTRUCTIONAL COMPUTING

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ABSTRACT

Neither experience nor interest in programming is prerequisite to making instructional applications of computers. In instructional computing, the computer is the means of instruction; the teacher instructs with a computer rather than about a computer.

This presentation studies the many instructional faces of the computer. Among its teacher-like faces are those of tutor, evaluator, instructional manager, and drillmaster. It may also assume the visage of a learning partner as it provides motivation, shares decision-making, and helps manipulate data. Finally, it may display the placid countenance of a faithful aide blessed with a prodigious memory and the patience required to pursue the most tedious task with unflagging zeal.

As late as 1975, the teaching of computer programming accounted for 60 per cent of the utilization of computers in the secondary schools of the United States. Cost, to be shattered by the retailing of fully assembled microcomputers in 1975, had limited the educational application of computers to teaching about computers. Computing services were available to but a small priesthood within education. Tardily, we have turned to the task of teaching *with* a computer -- of making the computer a means by which any teacher may improve instruction.

The purpose of this presentation is to overview those teaching activities in which the computer is the medium or tool of instruction -- that is, activities in which teaching is done *with* a computer. This connection between computers and instruction offers good things to every teacher regardless of the level of instruction or the subject area of interest. It serves the teacher whose goal is to be a user of computers. As we shall see, one need not be a frenzied computernik with a soldering iron in one hand and the latest book on obscure programming languages in the other in order to put a computer to useful work in education.

Teacher, Partner, Aide-de-Camp

Our investigation of teaching with a computer will reveal that the computer is a many-splendored thing. Each year we discover new applications of its talents. Although a definite list of its instructional uses may never be written, its application to teaching has revealed a three-sided educational personality which may be of help in understanding its total role in the classroom.

- The Computer as Teacher. When acting as teacher, the computer assumes the task of executing some specific component of the teaching act. Constrained by the instructions it has been given, it exercises principal control of the decision-making process which governs execution of that specific component.
- The Computer as Partner. This partnership means that the bounds of the computer's control of the teaching act are set in cooperation with individual users. Major decisions which control the teaching act are shared by computer and user.
- The Computer as Aide-de-Camp. Here the computer acts as if it were the one and only private in an army of generals. Its task is to perform as directed, not to direct or judge.

Although these three aspects of the computer's personality are not cleanly separated and have been described in other ways [1], they provide handy intellectual categories when studying or planning the instructional application of computers. I'll use them to organize the discussion of twelve kinds of instructional programs which should be of interest to teachers.

Programs à la Mode

One nice thing about instructional computing is that it can be discussed without reverting to computerese. While I do not deny the computer folks' need to create their own lexicon -- with such curious entries as *bit*, *byte*, *nibble*, *b.g.*, *glitch*, *chip-and-dip*, *motherboard*, *handshaking*, and *access* (as a verb) -- the explication of such terms can be left to others [2]. They and you must, in turn, grant me the right to define the single concept which is the subject of the remainder of this paper: the concept of *program mode*.

The *mode* of an instructional computer program is the primary class of instructional applications for which the program appears to have been designed. Since the use of a program is often beyond the control of the designer, it is quite likely that a program will be used in a manner other than that for which it was designed. Use, like beauty, is a function of the eye of the beholder. (Thus, it's not unusual to see someone use a spanner as a hammer.) By its nature, *mode* will not submit to a crisp definition. Neither will *fun*. I'd rather not do without either.

The taxonomy of program modes which follows is presented in an effort to help the reader appreciate the scope of instructional computing and to provide a means of classifying instructional computing programs. It does not report universal agreement of such classification (since such agreement doesn't exist); rather, it describes classes of use which the author has found of service as he has considered the problem of evaluating computerized instructional material [3]. At this stage, then, it is unrealistic to propose definitions of the various modes. What I will do is to characterize each mode in terms of the *purpose*, design features, or intended audience of the programs which comprise it.

The Computer as Teacher

There are four program modes which belong to this class: tutorial, reinforcement, testing operations, and instructional management. Teaching includes all of these tasks (and much more). The excellence with which a teacher would perform any of these tasks is dependent upon the teacher's training, experience, interests, "smarts", and dedication. The computer has neither "smarts" nor interests; its performance is heavily dependent upon how well it has been instructed by the programmer (i.e., its training). It contributes awesome speed, a prodigious memory, and endless patience to the delivery of these teaching services, but it cannot improve upon the fundamental quality of what it presents.

Tutorial Mode

When used in *tutorial mode*, the computer assumes total responsibility for the introduction of a new concept, generalization, or skill. Teaching takes place through a dialogue between the student and the computer in which the direction and level of the dialogue is continuously adjusted on the basis of student input. The problem for the designer of such a computer program is make the computer behave as if it were a knowledgeable and creative teacher engaged in a conversation with a single student for the purpose of helping that student develop important new thoughts. The dialogue must be rich enough to account for variations in student achievement, interest, and learning style.

In view of the complex nature of such programs, it should come as no surprise that the supply of them is meagre and disjointed. Although computer tutorials were among the first types of programs envisioned, they may be among the last realized. To date, the production of a body of quality tutorials has required the time and attention of a courseware team: subject matter experts, learning theory experts, program designers, and program encoders. However, current efforts to develop "lesson drivers" are of great significance since they will allow the volume production of computerized tutorials by classroom teachers by eliminating direct intervention by the middle men (learning theory experts, program designers, and program encoders).

One fundamental problem remains -- a problem born of equating a tutorial with a student-teacher dialogue. In an actual tutorial dialogue, both student and teacher are learners. Each asks questions, the nature of the teacher's questions being governed by what the teacher has learned to be effective by working with similar students in the past. While computers presently used to deliver tutorials do not learn from their experiences with students; research efforts in artificial intelligence being conducted at centers such as the Massachusetts Institute for Technology may soon offer some hope of a true student-computer dialogue. Should such work be incorporated into tutorial lesson drivers, computers could quickly become effective instruments of tutorial instruction.

Reinforcement Mode

Programs in the *reinforcement mode* are often called drill or practice programs. Such programs assume that the student has had previous instruction in the concept or process to be addressed; the job of the program is to maintain or refine the student's use of that concept or process.

There is much that might be learned about the word 'sarcophagus'. For instance, one might be interested in the word's etymology or its use in literature. One might want to study the word's referent in terms of its physical characteristics or social significance. Any such studies call for complex learning skills. If, however, the instructional objective is to learn to spell the word, the teaching procedure can revert to the basics of associative learning. In this case, what one needs is some kindly soul who will sit for hours pronouncing words and checking the student's spelling against that of some ruling lexicographer. We can then say that the student has learned to spell the target word when spaced presentation of the pronunciation of 'sarcophagus' (the stimulus) are met by the unerring verbal dissection 's-a-r-c-o-p-h-a-g-u-s' (the response).** This procedure, known as *drill*, has few exciting moments for the teacher. In fact, using a teacher to carry out such a tedious, unrewarding task is as unforgivable as using an antique gold watch as a paper weight. The computer, on the other hand, can be programmed to execute such exercises with a style that utilizes the extensive research on associative learning.

* These are programs which permit the subject matter teacher who is not a programmer to quickly produce computerized lessons.

** Of course, the response could be typed by the student.

And, because the computer is easily entertained, it will perform such services with unflagging zeal.

Whereas drill programs are used to reinforce simple associations, practice programs are used to reinforce processes or procedures. In mathematics, for example, students would practice step-by-step procedures for subtracting multidigit numbers. Science students need to practice the sequence of steps used in titrating an acid or counting bacteria. Craftsmen need to practice procedures for analyzing automotive engine problems, repairing a computer, or tuning a piano. Computers provide a carefully monitored environment in which a student may repeatedly execute the ordered sequence of steps which comprises any one of these logical processes or procedures, giving immediate notification of any student error and suggesting a method of correction.

Testing Operations Mode

Educators speak of the garbage-in/garbage-out error. If the concepts, generalizations, or skills that we attempt to teach are presented at the wrong time or in the wrong form (i.e., are garbage-in), the best we can hope for are rote echoings (i.e., garbage-out). The student is just a pipe through which ideas have passed without depositing an intellectual residue.

One way to prevent (or, at least, reduce) garbage-in/garbage-out errors is to use evaluation as the basis for prescribing instruction and for monitoring the effectiveness of that instruction. The procedure requires not only a deep understanding of the subject, students, and teaching materials, but also a great deal of time. If the teacher has the understanding, the computer can provide the time by means of programs in the *testing operations mode*. These programs offer a variety of services.

Tests must be scored quickly and accurately if they are to serve their purpose. As a teacher moves toward the use of many tests (in order to refine instruction), grading and the reporting of results can become a burden. Enter the computer Given that the responses are in a form readable by a computer (true/false, multiple-choice, matching, numerical response, or short answer), the computer can be used to score the test, point out "classic" errors to the students, summarize class results in tabular or graphical form, report statistical measures of group performance, and print individualized reports for the students. It can use the results to report what instructional objectives were mastered by whom and which need additional teaching.

Computerized testing operations include the generation of the tests themselves (with test keys for the teacher). Using its recall and cataloging talents, the computer can store and classify (by objective, level of difficulty, style of question, etc.) vast banks of test items. Using its retrieval skills, it can select, order, and print the items of tests tailored to a teacher's wishes. Alternate forms of a test are available for the asking. While test-item banking and test generation were once the features of large computer systems only, practical versions of these services now can be available to any teacher.

Computerized testing operations has its equivalent of the lesson driver. Known as *test item templates*, these recipes for generating many questions of a given form require only that the topic being tested has an explicit set of rules by which each question's answer can be generated. Such sets of rules are found in structured disciplines such as mathematics, grammar (any language), and the sciences; they are present to a lesser degree in the social sciences and mathematics. Simply put, item templates are sentences (or diagrams) with "holes" in them. The computer's job is to fill each whole in the template with a word, numeral, symbol, or drawing in such a way that the un-holed result makes sense. For instance, this problem was generated by a item template:

Estelle had 12 snakes. She gave 4 snakes to her friend
Koos. How many snakes did Estelle have left?

Can you guess where the "holes" were in the template that generated this problem?*

But a computer-assisted testing facility is useful for more than evaluating instruction (i.e., the performances of students and teachers). It can also evalu-

* In fact, the template consisted entirely of holes except for the three punctuation marks. That single template had the potential to generate over 400 000 different items of this kind!

ate the evaluation instruments themselves. A well-designed test processing system will generate explicit, simply-stated remarks which direct the teacher's efforts to improve the evaluation process. It will give item-by-item information about item difficulty and about how well each item discriminates between generally strong students and generally weak students. It will flag poor distractors on multiple-choice items, call attention to items that may have ambiguous wording, and alert the teacher to items which have been keyed incorrectly. Should these analytical remarks reveal the need to modify the scoring scheme to account for faulty test items, the desired changes can be made immediately and the tests reprocessed with almost no effort by the teacher. Such "admissions of guilt" in test construction/scoring are relatively painless for the teacher; they are viewed quite positively by the students.

Instructional Management Mode

The computer, in its role as teacher, can assume major responsibility for the management of the teaching environment. Programs in the *instructional management mode* attend to a myriad of teaching duties associated with assessment, record keeping, and prescription generation. These duties are complex and, for humans, time-consuming. Although skilled educators are required to establish the rules of instructional management, the actual execution of management activities can be automated quite nicely to the benefit of student and teacher alike. Computerized instructional management is the one hope for the teacher who is trying to teach students rather than classes (i.e., who is seeking to personalize instruction).

Instructional management is the new kid on the block of instructional applications of computers. It requires a thorough analysis (subject-matter independent) of the entire teaching act and the development of an integrated system of computer programs which comprise a single management facility.

The overall management task inherent in personalizing instruction can be simply put. It is to deliver each daily lesson (example: spelling the possessive form of a plural noun ending in 's' or 'z') of each major topic (example: spelling the possessive form of a noun) at each level (example: Standard 5) within each strand (example: grammar) of each curriculum (example: English) to each student (example: Koos van der Merwe) in one or more forms (example: lecture-discussion, text, filmstrip, computer lesson) appropriate to the student's level of achievement, interests, physical capabilities, and learning style. Whew! Viewed from the perspective of the secondary school teacher of English, the task needs to be further translated into specific activities for ??? students whose achievement is spread over five standards. Oh yes, and don't forget (a) to keep detailed records of academic progress for parents, administrators, and assorted government agencies, (b) to keep track of the physical location and condition of each teaching resource in use, (c) to regularly retire outdated resources, (d) to modify the curriculum in keeping with the latest decrees from the matric boards, and (e) to locate new resources and integrate their use into the revised curriculum.

The computer can be a wellspring of supervisory service within the arid land of management minutiae. To make the services flow, however, the teacher has to prime the pump. Specifically, the teacher needs to describe the content, organization, and learning resources of a curriculum. The curriculum must be spelled out in terms of measurable objectives, and there must be an instructional plan which includes the bases for guiding students through that maze of objectives along individually-determined paths. The system must be supplied with sets of questions to be used in diagnosing progress, monitoring study, and affirming learning. The computer's role is that of doer -- not thinker. Given the aforementioned guidance and information, however, it will manage the delivery of a curriculum for time unending.

The mechanics of computerized instructional management begin with the use of tests to diagnose a student's level of achievement or to identify specific gaps in the student's understanding of a given topic. This diagnosis is linked to a prescription-generation facility which assigns the student to the use of a specific learning resource. If that resource is of limited availability (e.g., a laboratory station, an expensive machine, the teacher himself), the computer can schedule the resource in a manner which optimizes its use.

The records kept by a computerized management system are used both to adjust the student's routing through a curriculum in terms of the student's achievement and to evaluate the effectiveness of the teaching resources employed. By keeping track of the academic progress or perils of individuals, the computer can generate reports which the teacher can use as the basis for modifying instruction, overriding computer decisions, changing the materials of instruction, or issuing reports to students or parents. Throughout it all, student-student and student-teacher communication will be supported by electronic bulletin boards (for public notices) and electronic mailboxes (for private exchanges).

The Computer as Partner

Programs in this class of applications could be said to exemplify educational power sharing. Program modes which include the principle of joint decision-making include simulation, instructional gaming and problem solving. In each, computer and user either cooperate or compete to resolve some problem situation. Whether competing or cooperating, the computer and user make independent decisions which result in important changes in the basic learning environment.

Simulation Mode

Some social twit has asked "Is there life after secondary school?" The query is followed by the observation that, if there is, the schools seem unaware of the fact.

The so-called "problems" addressed in the course of schooling usually bear little resemblance to life.* The procedure for solving the nastiest secondary school chemistry problem can, with rare exception, be found by reviewing the ten pages immediately preceding the posing of that problem. Solutions to problems in the real worlds of science, politics, business, or personal finance are rarely so convenient or tidy. The latter problems require gathering information, analyzing data, making decisions, suffering the consequences of poor decisions, and regrouping to try again.

Computer programs in the *simulation mode* provide something of an electronic slice of life. Instructional computing systems can support learning opportunities in which the student experiments in making decisions regarding public behavior, value-laden issues, allocation of time or money, experimental design, or complex scientific procedures. Through simulations, students make decisions and are informed of the results of the decisions made without being subjected to the real -- possibly catastrophic -- consequences of misjudgments. Simulations offer the opportunity to take learning to new levels by providing experiences which would otherwise be ruled out due to extreme expense, safety considerations, social consequences, or the time required for the actual experience. Most educators would have no trouble in seeing the value of being able to provide particular students with decision-making practice in

- using a credit card,
- raising cattle (wheat, whatever),
- resolving the issue of mining coal within a national park,
- defusing a political crisis,
- operating a small business,
- diagnosing automotive problems,
- building a bridge, or
- conducting radiation experiments on bacteria.

But however relevant that practice may be, it's obvious that the experiences are wholly unrealistic school activities. At least they were. Now they can be approached through computerized simulations.

Instructional Gaming Mode

The "lyrics" of rock music notwithstanding, the human animal generally is not enthralled by the repetition of simple-minded events. Yet the price of mastering a given subject seems always to include learnings that are most unattractive. The memorization of the basic facts of arithmetic must hold permanent title as the World's Dullest Academic Exercise. Confronted with teaching such homely items of knowledge, the teacher's biggest chore is to motivate the student to stick with the task. Clever teachers long have used instructional games to put a sugar coat=

* When, after all, was the last time you had to compute the square root of 37761.58 corrected to six decimal places and without the aid of a calculator?

ing on the drill pill.

Programs designed in the instructional gaming mode place internal emphasis on 'instructional' and external emphasis on 'gaming'. The primary purposes of such programs are to exercise specific concepts in a new context, to integrate the use of several concepts, and to develop general problem-solving skills. The gaming dimension of the program motivates and aids the realization of these purposes by establishing an environment which includes (a) the adoption of specific (if arbitrary) rules of operation, (b) the establishing of competition (or cooperation) with self or others, (c) the need to develop a winning strategy, and (d) the element of chance introduced by random events which force revision of strategies. Learning is monitored by the other player(s) -- of which the computer itself may be one. Interaction among the players informs a player as to whether or not a given move is technically correct or strategically wise.

Unfortunately, it is this interaction among players, often in a state of excitement, which makes it difficult to incorporate instructional games into the learning activities of some classrooms. The players' display of enjoyment of an activity may distract students who are engaged in less stimulating pursuits. Worst of all, some colleague, parent, or administrator may happen by; upon catching sight of students enjoying themselves (Horrors!), they may conclude that teaching has been abandoned in favor of good times.

The computer is less obstreperous as a participant in an instructional game, confining its outbursts to written comments, flashy graphics, or an occasional beep. Despite its subdued nature, students enjoy engaging it as a gamesman. In addition, the computer, sneaky instructional critter that it is, provides the monitoring and interaction that ensure learning. It can control its skill as to encourage the novice or to challenge the expert; it will even permit its opponent to select that degree of skill.

Problem Solving Mode

Regardless of field, problem solving skill certainly must be the ultimate goal of any curriculum. Again regardless of field, a problem-solving activity invariably involves the manipulation of data in search of information. In mathematics and the sciences, the data is often reduced to numerical form. Problem solving in other fields may deal with data in forms such as aural (music), graphic (art), literal (journalism), or olfactory (enology).

The teaching of problem solving in any field can be severely handicapped by human inability to process data rapidly and in sophisticated ways. In fields dealing with numerical data, the slide rule and, later, the electronic calculator greatly facilitated problem solving. The programmable calculator was hailed by physicists and real estate agents alike! Now the computer provides a general tool for manipulating a wide range of numeric and nonnumeric data at incredible speed and in ways formerly impossible due to human frailty (lifespan).

A program in the problem solving mode aids the user to explore and, hopefully, solve a complex problem. Note the words 'aids' and 'complex'. Problem solving programs do not solve problems of themselves. It is not their purpose of take a rigidly defined situation and crank out the solution to some textbook question about it. Rather, a problem solving program helps the problem solver as he examines the dimensions of a complex and perhaps poorly defined problem situation, conjectures about investigations that may provide useful information, tests those conjectures, analyzes the results, makes new conjectures, etc. The program is a means, not an end.

The heart of a problem solving program is an *algorithm** -- a step-by-step procedure which produces consistently excellent/correct results. There is a never-fail procedure for taking any whole number expressed in decimal notation and converting it to binary notation; the procedure qualifies as an algorithm. There is a procedure for approximating the bacteria count of a given culture (to within preset error boundaries); the procedure qualifies as an algorithm. Aunt Ella has a procedure for making a superb milk tart; since it doesn't produce consistently excellent results (even for Aunt Ella), it doesn't qualify as an algorithm.

* Or, if you prefer (and don't have a lisp), *algorithm*.

The problem solver is a user or developer of problem solving programs. As a user, the problem solver searches for the program -- or combination of programs -- which will help him to translate data and conjectures into information and reasonable conclusions. (For instance, every five years the National Assessment of Educational Progress gathers data regarding the reading skills of four age categories of Americans. Computerized problem solving programs assist the group in drawing conclusions from that data.) As a developer, the problem solver searches for the algorithm itself! Universities still search for algorithms that will make reliable predictions of academic success for the candidates applying for admission to various curricula. Employers in industry seek algorithms that will predict the on-the-job success of university graduates. I'm in pursuit of an algorithm for Aunt Ella's milk tart.

The Computer as Aide-de-Camp

While there will doubtlessly be need to modify and refine the descriptions of the program modes already discussed, the general modes seem destined for long lives as instructional applications of computers. They deal with major components of the teaching act and, as such, are unlikely to be deleted from consideration.

Aide-de-camp programs, on the other hand, are less stable. Many exist as elements of the larger modes already described but are mentioned here because they can be developed and used apart from grander applications. Some examples -- even entire modes -- may disappear as instructional computing matures, being absorbed as parts of more general programs or being discarded as outmoded (with no pun intended). Conversely, new examples and modes surely will be added as our experience and creativity in instructional computing begin to show.

Demonstration Mode

Programs in the *demonstration mode* require the intervention of an informed "manager" (e.g., a teacher) between the program and the user. They are designed to permit that manager to pursue the questions and suggestions of students by manipulating the conditions of a concept being developed. Sometimes called "what-if" programs, they have the unusual characteristic of being used as part of lecture/discussions between a single teacher and a large class. The teacher, using a lone terminal and a device which projects the video display onto a large screen, can call upon the computer to generate responses to what-if queries by students. For instance, if the program dealt with a model for poultry management, the instructor could use the computer to "introduce an epidemic", to manipulate market conditions, or to examine long-term consequences of a student's suggestion to alter a feed mixture formula. Mathematics and science teachers are able to immediately display, in graphical form, the results of changing specific parameters of a formula. Environmental geographers can explore student proposals for dealing with water pollution problems.

Demonstration programs are generally devoid of screen displays relative to their purpose or operation. This deliberate lack of text, while precluding independent use of the program by an inexperienced person, permits efficient realization of the program's purpose by an informed manager. The manager, who already has expertise in the topic explored by the program, depends upon external (written) documentation to explain the program's purposes, capabilities, and operation.

Informational Mode

There appears to be no item of information which is so obscure that no one is interested in it. In fact, its very obscurity may assure that someone will be interested. Moreover, several persons may be interested in the same item of information for different reasons. As an example, the identity of the consonant used most frequently in noncommercial articles of the Wall Street Journal might be of interest to (a) a cryptographer who wishes to use the Times to develop a code, (b) a mathematics teacher who is developing some probability problems for students, or (c) the host of a "trivia bowl" quiz.

Computer programs in the *informational mode* are designed to generate information. There are highly specific programs which will produce such things as lists

of prime numbers, entire calendars for any year since 1 A.D., assorted powers or roots of a given number, synonyms for a given word, lists of formulas or definitions associated with a given topic, lists of symbols used in a given field, lists of prime numbers between any two numbers given, the three dictionary words closest in spelling to a given word, the number of uses of a given word or letter within a block of text, etc. While such programs might be employed by a problem solver or might be attached to a program in some other mode, the face value of an informational program remains that of data generation.

Instructional Support Mode

The direct beneficiary of programs in the *instructional support mode* is, of course, the instructor. These programs are designed to provide a smorgasbord of instructional services relative to the generation of instructional products (e.g., worksheets, outlines for laboratory activities, newsletters, and progress reports), the location of resources (e.g., detailed listings of publications, materials, and persons), and the selection of products (e.g. textbook readability and computer courseware quality).

Effective instructional use of a wide variety of teaching resources (books, articles, films, slides, filmstrips, audio tapes, computer programs, laboratory activities, visiting speakers, field trips) requires an inventory system which allows the teacher and/or student to readily locate those resources. There is also a need to locate the addresses of firms which sell or repair the supplies or equipment used. Students must be scheduled for the use of some limited resource (such as the teacher); equipment must be scheduled for regular examination preventive maintenance, and replacement. Handouts must be prepared, revised, and reproduced in legible form. In summary, the conscientious teacher is confronted by many duties which reduce the time available for direct contact with students.

The burden of "nonteaching" duties can be eased markedly by a computer. Computerized inventory systems, developed to answer the demands of businesses, are now available for school applications. Computerized word-processing systems expedite the creation, improvement, and production of printed materials. In addition educators have developed programs which perform specific support services such as gradebook management, textbook readability analysis, evaluation of computer courseware, student scheduling, and the tailored generation of common classroom activities (word mazes, word scrambles, map exercises).

Programming Utility Mode

Programs in this mode are meant to be multipurpose tools. Each is a component that might fit several applications. While some of the *programming utility mode* do things that are of interest only to a computer programmer (e.g., create or delete data files, store data during chaining operations, clear specific areas of the video screen), others can be used as "stand alone" programs or, with a little help from a programmer, can be attached to other programs. Examples of such multipurpose programs include those which alphabetize lists, judge a student's spelling (i.e., allow the acceptance of student input which is conceptually correct but technically incorrect), or compare student's input with each of several acceptable responses.

A new breed of program in the programming utility mode is the lesson driver (mentioned earlier in reference to tutorial programs). These are very useful programs which permit the nonprogrammer to create original lessons of a given type (tutorial, drill, practice, simulation). There is, for instance, a lesson driver which will create a drill lesson in associating the elements of any two lists of verbal items (e.g., books with authors, chemical elements with their symbols, metric units with the attributes they measure). Another lesson driver generates vocabulary drill exercises for several languages. The user of either of these lesson drivers has only to supply the content (lists or words); directions which guide the teacher in supplying that content also are provided by the computer. Similar interaction between teachers and lesson drivers will produce tutorial or simulation lessons in a variety of topics and subject areas.

Whistles-and-Bells Mode

Whistles-and-bells programs are designed to allow the computer to show off. Put another way, these are programs aimed at acquainting teachers with those (perhaps unique) characteristics of a computer system which may be of value in developing instructional applications. They are, then, demonstration programs which run the gamut from carefully documented displays of system features to mindless exercising of color or sound capabilities to "wow" the consumer.

Whistles-and-bells programs are valuable insofar as they raise the user's sights and expectations with respect to lesson design. It is through such programs that the teacher can learn about, and reflect upon the instructional value of, features such as the following.

- color (number, quality)
- nonvoice audio (range and quality)
- graphics (quality of resolution, animation)
- voice audio (range, quality)
- screen formatting (split screens, protected)
- screen formatting (split screens, protected screen areas, reversed or blinking displays)
- keyboard versatility (standard character sets available, author-created character sets, alternate print sizes, special function keys)

Looking Back

The computer presents at least three faces to education: those of teacher, partner, and aide. The expressions we have seen on its teacher-like face include those of tutor, drillmaster, examiner, and instructional manager. It has also revealed the visage of a partner in learning as it accompanies the learner on simulated ventures into new environments, joins in the playing of instructional games, and helps in the solution of complex problems. Finally, it has turned to us the placid countenance of a competent aide devoted to making our teaching easier and more interesting. And who knows but that, as new educational applications are defined, the computer (having already done Janus one better) may turn still another check.

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NETWORKS, MICROCOMPUTERS, AND EDUCATIONAL COMPUTER SYSTEMS OF THE FUTURE

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ABSTRACT

No longer is there a question that computers will be used as educational tools. Falling computer costs have made economically possible today what was impractical just five years ago. With the development of the microcomputer, educators now have a choice between two different approaches to the use of computers in education. Which is the better approach, time-sharing using large computers, or the use of the independent microcomputer? This paper examines the advantages and disadvantages of both types of systems for the educator and, in closing, speculates on some likely developments in the near future and the possible impact on education of ever cheaper and more powerful computers.

What kind of computer is best for use in education, a time-sharing system or a microcomputer? That's like asking what car is best, a Volkswagen or a Rolls-Royce. They both can get you places, and the decision may depend on how much money you've got.

It wasn't long ago that there really wasn't a choice. The discussion did not focus on what kind of computer to use, but rather should computers be used at all in education? Well, it seems that computers are here to stay, and like it or not, they will be used in education.

COMPUTER DEVELOPMENT

It's sometimes hard to remember that the first computer was invented only 38 years ago, especially when one sees the latest generation of microcomputers with 16 or 32-bit microprocessors that fit comfortably on a postage stamp. But it is this rapid development of technology which makes the issues addressed by this conference so important.

Not long ago computers were simply too expensive to use as educational tools. Only large universities and exceptionally affluent secondary schools could afford to use them in any way. While there were various "brands" of computers available, there was nowhere near the choice of types of systems we find today. Educators at all levels and at all but the very poorest of schools now have a choice among many types of computers, and the variety of hardware available is certain to increase dramatically in the next few years.

To put things in perspective, it was exactly ten years ago this year that the first electronic calculators became available in the United States. I can remember in that year buying a simple four-function, eight-digit calculator for about \$100. A few weeks ago I noticed a food store in Newcastle offering a ten-digit LCD calculator with memory and six functions along with a digital watch for the price of 14 Rand.

Could you have predicted that ten years ago? Could you have imagined then that today you would be able to buy watches that wake you up with a song, keep track of the time in several time zones, tell you when your parking meter has expired, show you the calendar for the month, computer your biorhythms, multiply and divide, and even play games with you when you are bored?

Or, ten years ago, could you have imagined a computer you could program in BASIC, small enough to fit in your coat pocket, which would run for a year or more on hearing aid batteries and would retain its program memory even when the power was switched off?

Probably not. It's equally unlikely that we can predict the kinds of computer products that will be available in 1992, or even in 1985 for that matter. I don't wish to belabour the point, but we, as educators, often make plans for the future based on today's or even yesterday's technology. As a result, when we implement those plans, we are already out-of-date and behind the times. As difficult as it is to predict future advances, we must try, at least, to anticipate the technological possibilities of tomorrow. That way we'll be prepared to use those developments to the best possible advantage. To put it simply, we have to dream a little.

But we don't want our dreams to be based totally on fantasy, so before we go too far, it might be worthwhile to review the realities of today. What is available to educators now? What do educators need and expect from educational computing systems?

COMPUTER NEEDS OF EDUCATORS

Educators have unique needs when it comes to computers. Perhaps the greatest need is reliability. Of course all computer users desire reliability, but the businessman or researcher is only slightly inconvenienced by short interruptions of

computer service. For the educator who has planned a lesson based on computer availability, a disruption of service is a major disaster.

The teacher, professor, or student using computers for educational purposes may or may not know a lot about computers. They are often less than sympathetic with computers that don't operate properly when they want to use them. So reliability is very important in any computer which is to be used for educational applications.

The second greatest need is cost-effectiveness. Unfortunately, educators generally do not have a great deal of money. The best computer system in the world is of little use to the educator if it is not affordable by schools. Since there is very little, if any, evidence to indicate that a computer can teach better than a good teacher, any computer system which costs more on a per-pupil basis than a good instructor is unlikely to meet with wide acceptance. (Of course the situation is considerably different if enough qualified teachers are not available.)

Since most computer-based "lessons" display some text, educators need computers that are capable of displaying information rapidly. The ability to display graphics, at least in black and white, and preferably in colour, is also an important feature.

Educators also need courseware. Very few teachers have the time or expertise to develop their own courseware. Thus any computer which has a library of appropriate educational programs is highly desirable. There are, of course, other needs, but these are the most important. Let's keep these in mind as we review the two major types of systems available today.

AVAILABLE COMPUTER SYSTEMS TODAY

There is a wide variety of "sizes" of computers available today. For the purposes of discussion, we'll arbitrarily classify computers according to size into four main groups. Any such grouping is purely a matter of convenience, as there is really a spectrum of computer capacity with no distinct boundaries. At any rate, let's use the terms "main-frame," "minicomputer," "microcomputer," and "mini-microcomputer" to describe computers of various sizes and capabilities. These four groups of computers have characteristics as outlined in Table 1 on the next page. Large computers, falling into the first two categories, are mainly used by educators in a time-sharing mode whereas the smaller computers are generally used independently.

Time-Sharing Networks

Until recently most education institutions which used computers as teaching tools used main-frame or minicomputers in a time-sharing mode, and this still represents a very popular form of computer use in education, particularly in colleges and universities.

The cost of time-sharing, like most other computer-related costs, has been falling. It is now economically possible for most secondary schools, particularly those near metropolitan areas, to use time-sharing as a way of introducing computers into the curriculum.

Advantages of time-sharing. There are considerable advantages to the use of large computers in time-sharing mode. The University System of Georgia can be taken as a good example. All of the public colleges and universities in the state of Georgia are combined into a single computer network. In this case, the network is based not on one computer, but on three—two IBM 360s and one CDC CYBER.

Table 1
Types of Computers

TYPE	CHARACTERISTICS
Main-frame	Cost: R100 000 and up. Size: Quite large, but growing smaller. With peripheral equipment can fill a good sized room. Capabilities: Can support 50 to 2 000 time-sharing terminals. Vast data storage capacity and rapid number-crunching ability.
Minicomputer	Cost: R20 000 to R100 000 Size: About the size of a standard file cabinet. Size will vary, depending on peripherals. Capabilities: Can support up to 50-time-sharing terminals. Could handle the computing needs of most large (2 000+ students) secondary schools. Computing speed slower than a main-frame. Less data storage capacity.
Microcomputer	Cost: R500 to R20 000 Size: About the size of a standard office typewriter. Printers and disk drives take up more space. Capabilities: Some larger microcomputers can actually support a few terminals in a time-sharing arrangement, but generally micros are used as independent units. Data storage generally is on floppy disk or cassette tape. Internal memory is limited to 64K bytes in most models. Speed is considerably less than a minicomputer.
Mini-Micro	Cost: R100 to R500 Size: Fits in a pocket. Capabilities: Limited. Can be programmed, generally in BASIC. Internal memory in the range of 1K to 4K bytes. Computing speed very slow.

For research purposes this arrangement is ideal. As an example, Georgia Southern College is a school of approximately 5 000 undergraduates and 2 000 graduate students. Normally a school of this size would have rather limited computer resources. However, as a member of the state's computer network, faculty have unlimited use of three very large computers. Complex statistical routines, such as factor analysis, can easily be accommodated.

Not only is there the advantage of computer capacity in terms of memory and speed, but there is the added advantage of access to a very large library of statistical packages.

Another advantage is Georgia Southern College itself does not have to employ people to service and operate the computer. This support is provided by the network.

In summary, there are three main advantages to the use of time-sharing systems: (1) you have access to a much more powerful computer than you could otherwise afford yourself, (2) software can be pooled into a single large library serving many schools, and (3) on-line support is available for problems with both hardware and software.

Disadvantages of time-sharing. All of this is great for the professor who wants to do research, but when we begin to talk about using computers as educational tools—that is as a medium of instruction rather than as the object of instruction—there are problems. The number of terminals which can be simultaneously served by any computer is limited. In recent years at Georgia Southern, it has become very difficult to find an open port during the peak times of the day. It is very frustrating to both student and instructor to be told "all resources are busy" when you try to sign-on the network.

The solution would appear to be simple: increase the user-capacity of the system. This has been done several times during the last two years, but in Georgia, as in most places around the world, the demand for computer time has grown almost exponentially. Furthermore, you can only increase the user-capacity of a computer so much.

Now I don't want to overuse the Georgia example, but this clearly illustrates a typical problem the time-sharing systems: you as the user are not in control of the system. You are only one user among many, and you have to wait in line for your turn. Sometimes that wait is measured in milliseconds, but, unfortunately, sometimes it's much, much longer.

This brings us to another point. Since, as a time-sharing user, you are not in control of the system, you can never tell when the system is going to "crash" for one reason or another. It seems to me that the Georgia system always waits until the very minute that I have a class assembled around a terminal to demonstrate something; then it crashes. But regardless of when it goes down, it's always highly frustrating because you have absolutely no control.

Data lines, which are used to connect the terminals of a time-sharing system to the main computer, are another source of problems. There is, of course, an expense related to the leasing of telephone lines, and this can be considerable, depending on the distances involved. Aside from the expense, any data line restricts the flow of information between the computer and the user. This slows down the display of text. Furthermore, data lines often pick up noise and introduce errors of one type or another. Sometimes they don't work at all. Finally, a data line connected to a terminal restricts the mobility of that terminal. You can't easily bring a terminal into a classroom unless that classroom is especially equipped—a distinct disadvantage.

The PLATO System

At this point I want to say something about the PLATO system. PLATO is a time-sharing system, however, PLATO is unique in that it has been designed from the ground up as an educational system. I say this is unique because in most cases large computers are designed basically for research or business purposes and are then used almost as a second thought for educational applications.

Two of the three major problems with time-sharing systems have more or less been solved with PLATO. It is very rare, at least in South Africa, for the PLATO system to be overloaded. There are various PLATO systems around the world, some more heavily loaded than others, but an effort is made to make sure that the resources of the main computer are adequate to handle the number of terminals attached to each system. Here in South Africa, at least at the present time, there are far more resources available than typically are used. As a matter of fact, the South African PLATO system typically runs at about 30% of capacity.

Of course PLATO isn't perfect. Since PLATO is a time-sharing system, there are still the usual problems related to data lines. Data line problems have been a particular headache at Madadeni College of Education. Noise on the lines has been a consistent problem, and there have been times when one or more of the lines hasn't worked at all. Still, PLATO is probably the best educational time-sharing system available in the world today.

Microcomputers Used Independently

The microcomputer is really a very recent development, even in terms of the short history of computers. While microprocessors became available in the early 1970s, we can date the birth of the microcomputer to 1977 when the first ready-to-use microcomputer went on sale. Up until that time, the only way you could get a microcomputer was to build it yourself from a kit.

Most of the micros available today are based on 8-bit microprocessors. When you think that 8 bits can only represent the numbers from 0 to 255 that doesn't seem like much at all, but it's important to understand that numbers of much greater size can be handled. Larger numbers are manipulated in segments of 8 bits each. While this may not be of any concern to most educational users, it does have the effect of slowing down the computational speed of the computer. Extra steps are required for each calculation, and each step takes time.

There are several 16-bit microprocessors available today, and there have been reports that a 32-bit microprocessor has been developed. It is likely that the next generation of microcomputers, available within the next few years, will have vastly greater computing capacity and speed.

Advantages of microcomputers. For the educator, the microcomputer offers three basic advantages over time-sharing systems: (1) cost, (2) reliability, and (3) freedom from data lines. A microcomputer today will cost between \$500 and \$20 000. For most purposes, educators will find that a microcomputer costing about \$2 500 will be sufficient. There are no automatically continuing charges with microcomputers for the rental of data lines or for computer time. It is interesting to note that a 16 mm film projector costs about \$1 200 today. For the same amount of money a school can purchase a micro that can be used for some educational purposes and which can later be expanded. With microcomputers most schools in the world can afford to at least give their students some exposure to computers.

The reliability of most microcomputers is quite high. Since microcomputers are essentially all solid-state integrated circuits, there is very little that can go wrong unless you abuse it. If there are problems with a microcomputer system, it's usually one of the mechanical peripheral devices that causes the problem.

Another advantage is microcomputers are very portable. Since they do not need data lines, you can use them in any location where there is electricity, and soon that may not even be a requirement. Since they are light and relatively easy to move, they can be used in one classroom and then moved to another as needed. Microcomputers come to the student rather than the other way around.

While it is true that the calculational speed of a microcomputer is much less than that of a larger computer, seldom do educational users of computers need this capability. In many applications, microcomputers actually appear faster than time-sharing systems using very large computers because there are no data lines to slow data transfer. One inexpensive microcomputer I use frequently with my graduate classes in the United States is capable of displaying 1024 characters in 11.4 milliseconds. That's a rate of nearly 15 000 English words a second.

Disadvantages of microcomputers. There are, of course, some disadvantages to microcomputers. One problem is that you do not automatically have access to

software. Unless you plan to spend countless hours developing original software, you have to buy it, and the availability of good software for educational use on micros is limited. What is available is very expensive. It is likely that you will spend more for software than you will for the computer itself.

Another major disadvantage to micros is the limited memory. With 8-bit microprocessors, internal memory is limited to 64K (65 536 bytes), however this is usually adequate for most educational applications. As mentioned earlier, the computational speed of micros is much slower than full-sized computers. As an example, a large computer can sort a list of 200 student names alphabetically in less than a second, but a microcomputer using a BASIC interpreter might take as long as five minutes, depending on the sophistication of the program. Sorts of this kind are one type of routine often used in educational programs in which the microcomputer is at a distinct disadvantage.

Finally, if a school buys one or more microcomputers, they are on their own. Unlike a time-sharing system, there is no on-line support to provide assistance. This has been a major problem so far which has slowed acceptance of microcomputers by schools. Up to this time schools were rarely confident enough to strike out on their own unless one or more members of the faculty had quite a bit of expertise with microcomputers.

Mini-Microcomputers

You might wonder if it's even worth mentioning the mini-microcomputer. These are the microcomputers just recently introduced that fit in a pocket, run off batteries, and sell for \$300 or less. Certainly the capabilities of these computers are very limited. Are they of any value to educators?

The answer to the question is a firm "yes," if for no other reason other than students are already using them. Right now a mini-micro costs about \$150 minimum, but these prices will soon fall. Remember the price history of hand-held calculators! As the prices go down, we can expect more and more college, secondary, and even primary school students to buy them.

Since these devices, unlike calculators, are programmable in a real computer language (BASIC), they are real computers. There soon will be a whole generation of youngsters learning a computer language. How will this affect the curriculum? Are mathematics teachers ready for this? At least mini-micros ought to be used in schools as an object of instruction if not as a medium of instruction. We should be using mini-micros very early in school to teach programming concepts, and I don't think children of 10 years are too young to begin.

The capabilities of mini-micros as educational tools shouldn't be dismissed either. Simple mathematical drill and practice lessons can easily be programmed on them. For teaching basic math skills at the lower grade levels, mini-micros can be an inexpensive and valuable tool for the teacher.

Summary of Present Systems

In summary, there are two main types of computer systems most frequently used in schools today: (1) time-sharing networks based on large computers and (2) microcomputers used independently. There are advantages and disadvantages with each of these approaches and neither is clearly the better.

Time-sharing systems have great computing speed, vast memory and data storage capabilities, and provide access to software libraries. In the negative column, time-sharing requires data lines, which are prone to cause difficulties and restrict the portability of the computer terminal. Data lines also limit the rate of data transfer between the computer and the user. Additionally, the computer itself is under the control of others and may be unavailable when needed.

Microcomputers have rapid display capabilities, but are much slower when calculations are involved. Microcomputers are less expensive, at least initially, and are totally under the control of the user. However, microcomputers have limited memory and data storage and the acquisition of appropriate software is the responsibility of the user.

Hybrid systems. Perhaps the best approach is the use of a hybrid system. Microcomputers can be equipped with a serial interface, and when used with the right program, can act like a "smart" terminal on a time-sharing network. This gives the user the best of both worlds. When the speed or data storage abilities of a large computer are needed, you simply dial the right number on a telephone, place the telephone handset in a coupler attached to the micro, and you have all the power of the big computer at your disposal. What's more, programs and data can be entered on the microcomputer "off line" and then automatically "uploaded" to the large computer once connected.

With such a hybrid system it is also possible to "download" programs and data from the main computer to the micro. The micro stores this information and once the transfer is complete, the connection with the main computer can be broken and the micro can operate independently. Not many programs suitable for use on a microcomputer are presently available on time-sharing systems, and there sometimes is a problem of compatibility between versions of computer languages, but this is a software problem; the hardware is available today.

In the United States at least two computer networks have been established for owners of home computers. To use these systems, you must pay an initial subscription fee. An account is established, and you are provided with the necessary access codewords. Once you have that, you simply dial the computer on your home telephone and connect to your microcomputer. Once on line, you have access to a wide variety of programs and data, such as the latest weather forecast, news, stock market quotations, airline schedules, electronic mail, and even games. How can such public computer networks best be used for educational purposes? Today correspondence schools are popular. Could a school for adult education be established based on computer-managed instruction using home computers? Why not? The only real question is, who will do it first?

FUTURE TECHNOLOGIES

What about the future? What kinds of hardware can we expect in the years ahead? As mentioned earlier, this is almost impossible to answer specifically, but certainly certain trends can be seen.

Costs will fall. It is fairly safe to say that the overall cost of computing will continue to fall. In the last decade educational computing costs have fallen dramatically, and this trend is likely to continue throughout the coming decade. High competition in the computer industry assures that a given amount of money will buy more and more computing power. In the 1980s, more and more applications of computers in education will become financially feasible. It doesn't make sense to use computers to teach if the same thing can be done cheaper another way. But as costs fall, what doesn't make sense today will tomorrow.

More powerful microcomputers. Currently 8-bit microprocessors are the standard for the microcomputer industry. Already some micros are available that have 16-bit processors and 32-bit microprocessors will probably be available soon. As compared with 8-bit processors, these larger-capacity microprocessors have a larger and more powerful instruction set and are much faster. All of this simply means that the power of the microcomputer will increase by an order of magnitude by the end of the decade. Microcomputers in 1990 will be able to do what a good-sized minicomputer can do today, and at a fraction of the cost.

Advanced memory chips. The evolution in computer memory has been every bit as phenomenal as the development of microprocessors. Not long ago computer memory was hand-wired with each bit stored in a tiny magnetic ring. Three wires passed through each ring at right angles to each other. These wires were used to control and read the direction of the magnetic field in the ring. Imagine the labour in producing even 1000 bytes of such memory! It is easy to understand why computer memory was expensive.

Today semiconductor memory is used at a fraction of the cost of an equivalent amount of memory ten years ago. Today it's possible to put 16 000 bits on a single chip. Research being done today in the area of "bubble" memory promises exciting developments that may affect the entire design of tomorrow's computers.

Microcomputers have two types of memory: read-only memory (ROM) and random-access memory (RAM). Certain information vital to the operation of the computer, such as the operating system and the BASIC interpreter, are stored in ROM. This memory is permanent and cannot be changed. Programs and data which are temporary are loaded into RAM. The RAM in today's micros is erased if the power is interrupted, even for a second.

Tomorrow's microcomputers with bubble memory will not "forget" when the power is shut off. The advantages of that should be obvious. Right now programs and data that are not being used are stored on disk or tape, but such devices have been known to lose information. In any case, they are slow in transferring data as compared with internal memory. If the cost of bubble memory gets cheap enough, such devices may become obsolete. Micros may soon be designed to accommodate plug-in programmable memory cartridges of one megabyte or larger capacity, much like today's television game cartridges.

LCD displays. Most computers today display information on cathode ray tubes. While relatively reliable, CRTs are bulky, heavy, and power demanding. Liquid crystal displays (LCDs) may soon replace CRTs in terminals and micros. Already there are LCDs capable of displaying one line of text. It's only a matter of time until LCDs are available that can display a full page.

The advantages of LCDs are well known: they have an almost infinite lifetime (disregarding breakage), are clearly visible under most lighting conditions, consume very little power, and are flat. With an LCD display, a microcomputer of considerable power could be built into a small case and the entire computer powered by rechargeable batteries.

CONCLUSION

The possibilities for educators of the still emerging information technology are endless. There is little doubt that computers will affect education profoundly during the next ten years. At the present moment there is disorganization and chaos in educational computing, partly because of the explosive growth. In some ways educators have been caught off guard by the developments of the last five years. Even today few schools of education require their students to learn anything about computers.

The computer is a unique educational tool, unlike any that have come before. Most educational tools are designed with clear applications in mind. A film projector, obviously, is used to show films and a chalkboard is used to write on. The computer, on the other hand, comes to schools with great potential, but unable to do anything on its own. Educators have a responsibility to discover the best applications of the computer as a teaching tool. Some have charged that up until now, educators have abdicated that responsibility.

There's no longer any question that schools will use computers throughout the world. The questions now are how will computers be used and in what configurations. Teachers are the best people to help answer those questions. Let's hope they do.

COMPUTER-ASSISTED INSTRUCTION IN THE SOUTH AFRICAN CONTEXT

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ABSTRACT

The purpose of this paper is three-fold. Firstly a brief discussion is given of a system for Computer-Assisted Instruction, as conceived in the early 70's and implemented by the author on a micro-computer. Secondly results are reported of an experiment in CAI concerned with teaching Arithmetic at Std V level to black children. The objectives of this experiment were: (a) to prove that the available CAI system was a workable tool for instruction by computer; (b) to show that the technique may be successfully used in the area of black education at primary /secondary level; and (c) to experience the practical problems of introducing CAI in this area. The first two objectives were achieved. Finally the paper considers the feasibility of the use of the computer as an instructional tool in the South African situation, and concludes that a local network of micro-computers will probably have the best chance of making a noticeable impact on the educational problems of this country. Furthermore the production of course materials should be left to the free enterprise system, but such materials should be evaluated by an expert body.

INTRODUCTION

Computer Assisted Instruction (CAI) has been with us for a long time, in fact almost as long as computers themselves. For example in 1959 Alfred Bork developed a program involving electrons going through the atmosphere, using an IBM 1620 <1>, and he has never stopped producing teaching programs for Physics since! In the early years experiments in CAI were made by people who had ready access to computers, ie. teaching staff at universities. Consequently many applications of the computer in education were developed for the tertiary level.

If one wants to classify the modes of CAI, ie. the ways in which the technique is used, it is possible to distinguish between

- drill-and-practice
- tutorial
- games and simulation
- free interaction.

CAI as applied at tertiary level is mainly concerned with simulation of laboratory experiments, which would be too costly, in resources and/or time, to carry out physically. Naturally the other modes could also be used in a university environment, but (a) free interaction, as formulated by Zinn <2> requires a strong base of Artificial Intelligence programs and techniques, which currently are available in only certain specialised cases, and (b) drill-and-practice is not the ideal technique to teach students at tertiary level. Furthermore, to write non-trivial tutorial programs is a very difficult task indeed which does not seem worthwhile in terms of the potential results to be achieved. Therefore I think that, although one can understand why CAI or more respectably, Computer Assisted Learning started at university or college level, this is not where most of our efforts to introduce CAI should be directed.

Before pointing out where CAI should go in this country, I shall briefly describe my personal experience in this field.

THE DESIGN OF A CAI SYSTEM

Any system for computer assisted instruction has at least two components or subsystems:

- a subsystem to prepare course material;
- a subsystem to deliver course material.

In addition, coupled to the latter system there may be a system to collect and analyse data about the use of the CAI system. The information gathered may be used to guide the users through the course material and may also provide progress reports, as well as evaluation reports of both the users and of the course materials. Although such reports are very important for the management of the instruction process, we are not really concerned with this aspect of computers in education.

My first contact with CAI was made when I spent my sabbatical leave during 1974/75 at the Technische Hogeschool of Delft, the Netherlands. In the early 70's the mini computer had made its appearance and the Informatics group in Delft was interested in showing that a dedicated mini would be more suitable for CAI than a main frame computer which has to be shared by many different users with higher or lower priorities. Van der Valk <3> had defined the specifications for a CAI-system, and just before I arrived a PDP 11/45, with 16K words of memory, disks and the usual other peripheral equipment had been installed. Being in a technological university we naturally wished to produce a well-engineered system, but in retrospect I don't think that, in programming terms, we knew what that meant!

Considerations about efficiency and economy show that preparation and delivery of course material are separate activities. Ideally both activities should be machine independent. If the system software is implemented in a standard high-level language like FORTRAN, machine independence may be achieved to a large extent, but to some degree the facilities which the CAI system can offer are always determined by the facilities of the operating system, and this varies from one computer to the next. Hence when one considers a CAI delivery system, this must be done with a particular type of machine in mind. However, to design and implement a course delivery system is a one-time effort, which should be done by a computer systems expert.

On the other hand the preparation of course material is a task for an education expert, who in most cases will not be a computer expert. This fact, which is often overlooked, was recognised in that a large number of special languages made their appearance in the early 70's, eg. TUTOR, COURSE WRITER, CAN and PLANIT. These languages try to make it easy for the non-programmer education expert to prepare courses for delivery by a computer.

In 1974 we were faced with the situation of a variety of languages, so-called author languages, and a variety of computers, from which a choice had to be made to create a CAI system that could be used as widely as possible. We decided to design a "soft" machine, and to implement it in a standard

high-level language. This soft machine could execute a program, representing a course, in machine code. The course is initially within in one of a number of available author languages (in practice PLANIT or TUTOR) and is then translated into a specially developed assembly type language called CAIASCO (CAI ASsembler COde). A program in CAIASCO is subsequently converted in machine code, and organised into a data structure which allows quick access to any part of the course.

The system as implemented, is described by Wiechers <4>, and is currently available on a PDP11/34. It will accomodate a maximum of 16 students who may share the facilities of the system, but who work individually, each on a different section of the same course, or on (a limited number of) different courses. Preparation of course material is done using PLANIT as the author language.

PILOT EXPERIMENT IN CAI

The University of South Africa acknowledged the importance of computers for education by granting the establishment of a Research Unit for Computer Assisted Instruction, located in the faculty of Education. The unit had as its task to plan and conduct an experiment to compare the effectiveness of computer assisted instruction in respect of arithmetic (in particular addition) with traditional teaching methods, for black pupils at the Standard V level. A full report on this experiment is available <5>, and I will briefly review the background and the results of the experiment.

The experiment was a comparative, didactic study based on the experimental group/control group approach. The method used was as follows:

- part of this STD V syllabus, the elementary arithmetic section, was implemented as a teaching program employing the drill and practice mode, with a tutorial approach for remedial sections that could go back to as far as the Std II level. The experimental group worked through this program in about eight half-hour sessions at the terminal, whereas the control group was taken through the same material using the traditional way of teaching by a black teacher;
- an attempt was made to test using standard techniques, the pupils' attitudes towards mathematics;
- before and immediately after the experiment both the experimental and the control group were tested to determine their performance in the basic arithmetic operations, in order to determine if any improvement in skill could be shown;
- six weeks later the same performance test was conducted to

see to what extent the additionally acquired skill had been retained.

In view of the nature of the target group, black children at primary level, it was decided to conduct the experiment in a school in a black township (Mamelodi). The picture on the next page shows the experiment in progress. This proved to be a very good decision, but in a negative way, because it showed all the problems one may expect to encounter when introducing computer assisted teaching in a black environment:

--of the 70 pupils initially tested, 21 had left the school by the time the experiment was conducted and only 15 valid pairs of pupils could be identified;

--the computer, located in the center of Pretoria, experienced a lot of problems keeping in contact with the terminals in Mamelodi:

--low quality modems, which often failed

--archaic terminals

--thunderstorms causing power breakdowns

--very poor telephone lines and facilities;

--high absenteeism of pupils.

As a result no significant conclusions could be drawn. However before the experiment proper we ran two pilot experiments, using an experimental group only, consisting of six black children in Std V which were brought to the computer site on a daily basis over a two-week period. On average a total of 4 hours was spent at the terminal.

The children were chosen out of a group of 200 children at Std V level, who were given a diagnostic test <test A>. This test consisted of 50 addition sum, and the time allowed was 20 minutes. They were also given a speed test <test B> on all four arithmetic operation, being allowed 4 minutes per operation. Of the six children chosen 2 were above average, 2 were average and 2 were below average. After working through the program on addition the children were again put through the diagnostic tests. To test the retention, a class of 34 children plus the six involved in the experiment were tested again one month later. The results are given below:

Pupil	Test A			Test b		
	1	2	3	1	2	3
1. Johanna Mnisi	94	100	98	80	92	94
2. Benjamin Simelani	94	100	94	68	76	81
3. Violet Mahlangu	62	74	56	51	57	55
4. Anelia Magagula	54	82	78	49	57	63
5. Steven Geel	40	94	80	47	54	59
6. Benjamin Themba	62	78	84	44	62	61

1: before CAI course

2: after CAI course

3: one month later.

The average results are as follows:

	Test A			Test B		
	1	2	3	1	2	3
Total	406	528	490	339	398	413
% improvement of 6		30	21		17	22
% improvement of 34			2			10

There is a method to grade pupils, expressed in terms of standard + no of months, based on the results of test B. For the 6 children, who all were Std V at the time, the grading before and after CAI experiment was as follows:

Pupil nr	Before	After
1	4.7	5+
2	3.10	4.3
3	2.7	3.2
4	2.5	3.2
5	2.3	2.11
6	2.0	3.2

It is clear that, when the children work under good conditions, without demotivating events, excellent progress is achieved in the acquisition of skill in arithmetic using the CAI technique. A similar run was carried out with another six children with almost identical results. Though statistically perhaps not very significant, there is nevertheless sufficient indication that the computer can play a useful role in the particular area where it was applied.

CAI IN THE SOUTH AFRICAN CONTEXT

The experiment described above was carried out to test our CAI system and materials. Certainly not to prove CAI as a valid teaching technique since this has been shown by many investigations! But there are many techniques to transfer knowledge and skill. Hence we should now consider how and where CAI may be best applied in our local situation.

There are many studies comparing the effectiveness of CAI as

an instructional medium with others like lecturing, programmed instruction, audio visual instruction, etc. Results have shown that students can effectively learn from all these media, but there seems to be little significant difference in one method over another <6>. But CAI, as a supplement to traditional instruction, as a remediation vehicle, and for drill and practice has been found to be an effective medium for improving achievement levels in many studies <7>. It has also been shown to be of special value in improving performance to younger, to slower (low aptitude) students, and to those with special learning difficulties, e.g. the deaf, paraplegics.

These general findings lead to conclude that CAI may be applied in chiefly two situations.

--in normal teaching where there exists a lack of (qualified) teachers; in this case CAI replaces the normal medium of instruction.

--in remedial teaching, where the results of normal teaching practices have to be reinforced or even remedied; in this case CAI supports the normal medium of instruction.

In this country there is a need for both. This is very clearly indicated by statistics given in the de Lange report on the Investigation into Education <8>. In 1978 there were a total of 4223651 (69,2% of the total school-going population) black children in primary and secondary school in South Africa. These children were served by 64 049 (44,7% of the total number of primary and secondary school teachers) teachers, giving a pupils/teacher ratio of 48,5. This compares with ratios of 27,2, 29,5 and 20,2 for asians coloureds and whites respectively. Thus there is a tremendous shortage of teachers for black children. But the situation is even worse than indicated by the disparity in numbers. Of the 64049 black teachers there were 53461 with a teaching certificate, but of these only 18,6% had at least a Std X qualification. There were also 12624 teachers without a teaching certificate, of which 15,3% had at least a Std X qualification. The corresponding percentages for whites, coloured and asians were 100/100, 38,7/36,6 and 86,7/60,0 (with/without a teaching certificate). Clearly the level of education of the black teachers is very much lower than that of their white or asian counterparts. Moreover the numbers involved are such that it would be unrealistic to expect that the problem can be rectified by traditional means.

The de Lange report recognises the role of educational technology when it states:

"The role that educational technology can play in improving the quality of education bridging the gaps and expanding non-formal education has been indicated and it is felt that the service, ..., should be developed. Action research

on computer assisted instruction, and the involvement of the Post-Office and the SABC should be given priority."

I see no better motivation to go ahead with our efforts to develop the computer as an instructional tool, in particular in the area of primary and secondary black education. The next question immediately follows: HOW?

To answer this question we should take due regard of the financial aspects of the education problem. Education is very costly and all education authorities are continually short of money. It would be unrealistic to expect the State, which is responsible for financing education in this country, to provide more than a small fraction of its education budget for educational technology. In this respect it should be remembered that if a certain provision is made for one school of a particular type, that provision is made for all schools of that type under the jurisdiction of the education authority. Hence the large numbers involved are always going to be a restrictive factor. In my opinion one should look for the cheapest possible means to offer CAI.

As a very wild guess I would suggest that the most we may hope for is funds equivalent to the cost of one teacher per school. If such a contribution could be sustained over a few years, one may expect to provide equipment to the value of, say R20000 to 50000. This equipment should provide useful help in a school with anything up to a 1000 pupils. In addition the education authority needs to invest into a central facility for preparation of the course material. In a nationwide basis, this item is however negligible compared to the total cost of equipment for delivery of CAI.

Clearly a proper study should be made to estimate the total cost of introducing CAI on a national basis, but this is outside the scope of this paper. Here we are merely interested in defining the nature of the system which will have a reasonable chance of being used in one specific situation.

In order to get a partial answer to this question, let us suppose that each pupil in a school of 1000 children is allowed one half hour per day at a terminal, and that the activities could be scheduled in such a way that 10 hours per day could be used for CAI. Then 20 children can be accommodated per terminal, so the school would need 50 terminals. Such a terminal would consist of a processor, a screen and a keyboard, and form a node in a network, which contains, apart from the fifty terminals, a master processor, a printer and a mass storage device like a 20 MB disk for storing course material and performance data. It should be possible to supply such a system for about R50 000.

It should be clear that a system as outlined above requires

that the necessary course material to be readily available. To develop this is a tremendous task, comparable to the efforts which go into the writing of books. It would be too costly for the education authority to provide CAI courseware. The production of CAI materials should be left to private individuals who are capable and willing to undertake this, and get their rewards from the sale of their work in the open market. This is quite the accepted thing for textbooks, and it is likely that book publishers will also become the publishers of course materials to be presented on computers. However the authors of such material require detailed guidance about course contents and standards of presentation. A central body should be set up which will develop specifications for materials intended for a particular target population. This body should also be in a position to evaluate and approve acceptable material. The authors could enter into contracts with publishers and the central body would approve the products marketed for use in schools. It is expected that the free enterprise system would supply whatever is needed to use the computer in educational process.

Another aspect to be considered is the training of teachers in the use of the computer in the classroom. Clearly the material presented by the computer must form a integral part of the teaching program. The teacher should be able to decide when a pupil should go through a given program, and how to use the facility so that it really reinforces what the teacher attempts to do.

There is a close relationship between the materials available for CAI and how they are presented on the one hand, and the prescribed syllabi and approaches to teaching as prevalent in a given situation. This makes it unlikely that materials available from elsewhere, e.g. the UK or the USA, are suitable for the local market. It is my opinion that materials should be developed locally, by local experts, for the local market. And this should be quite independent of the systems offered for preparation or presentation of CAI courses. One of the problems that must therefore be faced is that the production of good relevant coursework must still be done!

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THE SCIENTIFIC BASIS FOR THE USE OF COMPUTERS IN EDUCATION AND TRAINING

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ABSTRACT

The paper examines past and present educational technology including audio-visual devices and current Computer-Aided-Instruction, using flow graphs and basic Cybernetic principles and identifies shortcomings in these technologies.

Various educational strategies, in particular the merits of group and self-paced instruction are next discussed. Their integration with the multi-media approach, books, computers and human teachers exercising on-line monitoring and control through a systems approach, is next considered.

Finally, a computer based educational model is described for overcoming the shortage of teachers by using them more effectively.

A scheme involving broadcast television and computers for mass education is also proposed.

1. Introduction

There are many educational problems facing South Africa at this stage of its development:

- 1.1 a moderate shortage of white teachers, due to the drift of teachers into industry and commerce
- 1.2 a general shortage of qualified black teachers at a time when large scale education is required
- 1.3 the ever rising cost structure of education

A commonly held belief is that technology will provide a solution to these problems. Our point of view is that technology cannot successfully be applied piecemeal, e.g. by bringing in one more magic box into the classroom, or by viewing education as a problem in automation, i.e. by simply attempting to replace the teacher with a computer. Education is an integrated system which must meet the viability requirements of complex systems in general and social cybernetic systems in particular. Besides cost effectiveness, it must be sufficiently versatile to accommodate the large variety of teaching strategies, while being sufficiently flexible and simple in the hands of the educational authorities to enable the system to quickly adjust to the dynamic nature of education.

2. The Past Role of Educational Technology

We list the following technologies which in the opinion of many have not come up to the initial expectations over the past 25 years:

- 2.1 16mm films - general utilization is low
- 2.2 Programmed textbooks - few published at present
- 2.3 Teaching machines - after initial promise, ceased production 10 years ago
- 2.4 Closed Circuit Television - except for specific training institutions, hardware is generally under-utilized
- 2.5 Broadcast Educational Television - swing away from hardcore learning to "enrichment" programs
- 2.6 Language Laboratories - moderate success in institutions of higher learning where student motivation is greatest
- 2.7 Computer-Aided-Instruction (CAI) - it is now approximately 20 years after its inception, and apart from theorizing, one would have expected by now firm conclusions that CAI is superior to conventional teaching, for general educational purposes.

CAI is defined here as the system used up to now where an application program is stored in the memory of a computer; the student sits in front of a terminal which has a screen and interacts with the program; the student in most instances responds to a question on the screen using one or more characters but seldom more than one word.

Gallese [1] recently wrote in the Wall Street Journal that so far evaluation of CAI is lacking. Similarly, other articles intending to promote the use of computers for CAI admit that "The ultimate success of microcomputer-based learning will depend on a convincing proof of its effectiveness." [2]

The obvious two questions to ask are:

- (a) Why have these technologies not yet provided the answers?
- (b) What is the best role for the computer?

3. Basic Shortcomings in Existing Educational Technology

Many reasons have been advanced in the past for any failures of the technology mentioned in Sec. 2.

The blame is usually put on the teachers, with assertions that they are afraid of being replaced by technology; that they are not industrious enough to want to use it, or more vaguely, "that they have failed to utilize it properly, or have used the wrong programs". Indeed protagonists of these technologies vary in their pronouncements from the diplomatic statement "the future teacher will be a manager of resources and not a teacher in the conventional sense" to "I don't know much about the quality of teachers in your country, but I am afraid that here....".

It is believed that the problem in fact arises from a failure to understand that the teaching process, like many other social processes, is a cybernetic one. As with other viable self regulating systems certain essential basic features are necessary for its proper operation. In educational terms this implies that:

- 3.1 education authorities and teachers formulate educational objectives which change according to circumstances.
- 3.2 teachers, with or without the aid of technical devices, make available to students material related to the educational objectives, and in addition supply or enhance motivation.
- 3.3 students learn in groups and/or individually depending on several factors which are discussed later.
- 3.4 the learning process is enhanced in effectiveness when students interact, rather than sit passively during the learning process.
- 3.5 during interaction students receive feedback and sometimes reinforcement on their actions.

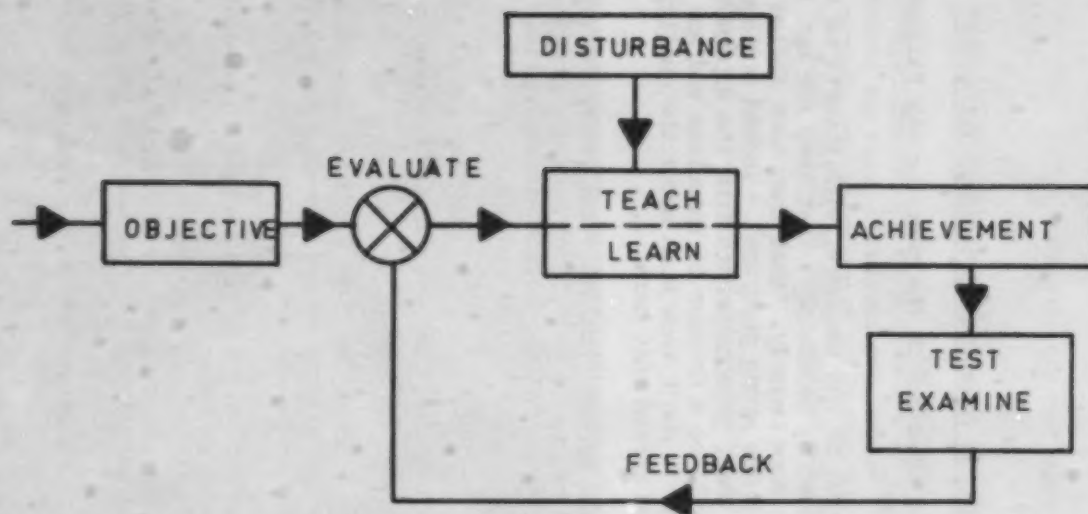


FIG 1.

3.6 teachers receive feedback during the process, and additionally set examinations in order to measure student achievement which indirectly also evaluates the material being presented and the method used.

3.7 teachers compare the students' achievement with the original educational objectives and apply corrective action where necessary, in order that the general performance of the students should correspond more nearly to the educational objectives.

Points 3.1 to 3.7 constitute a complete cycle of operation.

Fig. 1 shows the well known elementary self-supervisory system or feedback loop. [3] The block marked "objective" is the "input" or "desired output"; the block marked "teach/learn" is the "process"; "achievement" is the "output"; "test/examine" represents the "sensor"; while "evaluate" represents the "comparator" between the desired results and the actual achievement.

For a system to function effectively there are several important requirements, in particular:

3.8 it is preferable for it to be of the multi-loop type in order to help to stabilize each varying function separately. In education there are such separate loops for the student and the teacher.

3.9 where possible the evaluation must preferably be done quantitatively on a continuous basis.

3.10 the faster the response time - the more effective and stable is the system.

Let us examine some information flow charts in current educational technology or situations.

Fig. 2 shows the conventional classroom. There is only one fast response feedback loop when the teacher asks the students a question and only one student responds.

In a language laboratory part of which is shown in Fig. 3, every student is active, however, there is no measurement or comparative records of performance, and only subjective evaluation by the student of his own performance (shown by the coil in Fig. 3). The teacher's role is relatively minimal during the process as his useful intervention is possible only when by chance he happens to listen in to a student committing an error.

Fig. 5 represents a teaching machine or CAI where a student sits in front of a terminal. The object of the teacher here is to have a stored program which is so clever that it is at least as good as a personal teacher. The actual teacher has no on-line function. The philosophy is one of automation, i.e. trying to automate the labour intensive element in education - which is the teacher. We will presently examine the use of computers in this mode in greater detail.

4. Group and Self-Paced Instruction

Many beliefs have come and gone in education, from the best way to teach reading or to do multiplication, to the fears expressed of the consequences of the fountain pen and later the ballpoint pen. In a highly subjective field such as education in a free society, this is unavoidable.

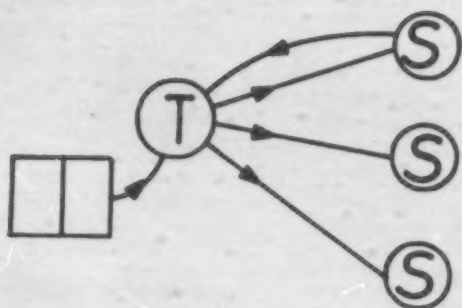


FIG 2

Ⓢ = STUDENT
 Ⓣ = TEACHER

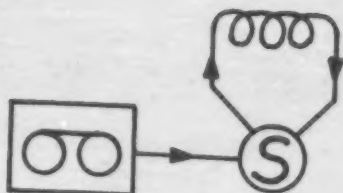


FIG 3.

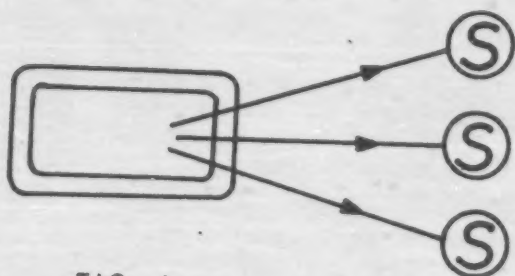


FIG 4.

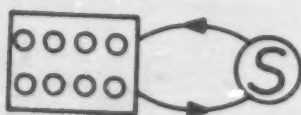


FIG 5.

Currently a great deal is written about the merits of self-paced instruction. To redress the imbalance it is worth stating the case for group instruction, quite apart from any economic considerations.

4.1 The sociologically based subjects are best taught in groups. This includes management training, safety, health care in industry; or history, communication studies and aspects of language teaching in schools.

4.2 One of the most important objects of education is the "socialization" of the individual student, i.e. to make him function in a society comprising a spectrum of individuals with differing abilities. This requires the student not only to react, but to witness how others react to problems, situations, new information and controversy and how a teacher employs approval, sympathy, empathy, prodding, reprimands, counter arguments and a host of other psychological aids for stimulation and motivation. The idea that one can educate (as opposed to giving the student narrow training) by isolating the student from his peer groups and placing him in front of a terminal is, to many, a contradiction of the object of education.

4.3 A student learns from the mistakes of fellow students.

4.4 Besides the fact that teachers make both oral and visual presentations, there is important information transfer which occurs in an "eyeball-to-eyeball" confrontation between a human teacher and a group of students by voice inflection, body talk, etc. which cannot be matched by a computer terminal.

No computer can sense an expression of tiredness, frustration, bewilderment, boredom, amazement, etc. on the part of a student, and react accordingly and timeously.

4.5 Group psychology can be used to modify learning behaviour of individual students.

Invariably both group and self-paced work is necessary.

5. Particular Problems of CAI

5.1 Responding under CAI.

In conventional CAI the student usually responds to a question with a single word or a single letter. However there is a limited use for such teaching, as a full sentence reply to a "why" question or a "how" question is often more important than the single word response to a "which", "what", or "when" question.

Furthermore, when teaching complex ideas, the information presented through CAI programs must often be convoluted in order that a single word response can be elicited. In other instances, the subject matter is often presented in such small steps that the student is bored, or the questions become so verbose that the essence is obscured.

5.2 The courseware problem.

No large catalogue of software is useful if none of it is directly applicable to one's needs.

It is commonly agreed that it takes between 100 and 400 hours of programming to produce one student contact-hour of CAI. This represents an investment which rapidly outstrips the cost of the hardware.

Courseware is generally not transferable. Sugarman [4] writes that of the 16,000 hours of CAI material for a system well known in the Cape (which is vastly more than any microcomputer company can claim) only 4000 are "good". And where are they used? Primarily at the original site in Illinois where it was developed.

Prof. Nievergelt [5] of the University of Zurich (who taught at the University of Illinois) states "Today it makes no sense to start a CAI project unless one is willing to write most of the necessary courseware".

Even in a subject like Latin, which one might have expected to be transferable, Millar [6] of the University of the Western Cape writes that the American Latin program used is actually unsuitable as it was devised for different objectives; the lessons are too long; they have not been written inside the context in which they are being used; they presuppose a certain degree of knowledge and sophistication, etc.

Not only is courseware seldom transferable, but once written is soon outdated or ignored. There are many reasons for this. Education is a dynamic process. Not only are some subjects generally evolving through new knowledge, but a teacher's own understanding of the same subject is constantly improving. Educational theories as well as the teacher's own interpretation of these, are also constantly developing. Thus, teachers continually question and seek to revise material.

Finally, witness the fact that even in elementary arithmetic (where no great breakthroughs are expected!) a large number of new textbooks is published every year. The motives for this certainly include the desire of many dedicated educators to communicate their own individual, different and, in their experience, successful methods to their colleagues.

There are no perfect textbooks or computer programs. In a free society educators must be free to choose from a variety of alternatives or be in a position to easily create their own.

Attitudes in South Africa are no different than in the United States. Prof. R. Kinsky [7] speaking on Radio Today earlier this year, said, "We are so infinitely independent in most of our States that it is hard to get together a large enough body of people to agree to a single system that could then make use of it. Everyone wants to do his own thing."

5.3 The choice of hardware for presenting information.

Although currently the means for presenting the material to be learnt when using computers is via a Video Display Unit (CRT), we believe that books and the multi-media approach are often preferable when forming part of an integrated computer based system as described later.

5.3.1 A book is portable so that a student can prepare himself before a lesson and review the lesson thereafter. He can use it to study at school, at home, enroute, and in any orientation so that learning is therefore not only confined to the classroom.

5.3.2 Printed notes can be created or modified by a teacher without any special programming knowledge being required.

5.3.3 Printed characters and pictures are clearer and have better definition than those on a computer screen. The time delay in forming pictures on a screen is often distracting.

5.3.4 Books are relatively inexpensive so that different teachers or schools are free to use different books and to change them at will.

5.3.5 A textbook requires minimal maintenance.

The multi-media approach on the other hand advocates the use of the best medium of presentation for the job at hand, rather than forcing the use of a VDU.

Thus a photographic picture of an object in the form of a 35mm slide, is far superior to what is possible and cost-effective using computer graphics. Similarly a CCTV presentation of say a castle in a history lesson, or the stripping of a carburetor in motor mechanics, cannot be matched by computer graphics, neither in quality nor in cost.

The VDU is warranted only in graphics of the interactive variety which involves abstract concepts, or the simulation of a process which is too expensive to simulate with physical models. This is however an exotic class of application. To quote Dr. J. Poore [8] Director of the Florida State Computing Center, "When one is talking about basic educational needs, graphics performance is not of great importance."

5.4 CAI in the hierarchy of control systems

Viewing CAI as an exercise in automation, it is well to consider the hierarchy of feedback control system and judge its performance accordingly.

The hierarchy starts with alarm protection at the bottom and progresses in sophistication to adaptive and learning control systems of at the top.

Except in very isolated cases such as drill and practice in arithmetic (where a random number generator is used to create problems to be solved by the student) human intervention is needed to change the teaching learning parameters inside the process (the teacher/learner block in Fig. 1), so as to adapt to the dynamic nature of education discussed earlier or to changing objectives. This is done by programmers. Unfortunately programming is a slow process with the consequence degradation of the performance of the system as a whole.

6. The Communications Approach

As an alternative to the automation approach of trying to program a computer to behave like a teacher, we address ourselves to the question, "What are the human limitations of a live teacher that can be overcome by means of computer based technology?"

A fundamental human shortcoming is that one can speak to many simultaneously but listen to only one at a time. However a computer can "listen" to many simultaneously for all intents and purposes. The aim is therefore to give the teacher better on-line monitoring and control of the teaching process. This is a communication and not an automation approach.

From this point of view we look for ways and means for the computer to open up communication lines; to sort messages, collate responses and provide individual objective reinforcement to each student; to display immediately (not at the end of the lesson) to the teacher information concerning the errors being committed as they occur in self-paced learning; to provide vital feedback information on overall understanding in group learning; to help measure performance by evaluating and quantifying responses; and to record some, or all of this information as a basis for remedial action. In a system based on this concept, the computer is used to extend the senses of the teacher, thereby effectively multiplying the presence of the teacher instead of attempting to eliminate it.

This communication approach leads naturally to the idea of encoding data on the actual materials used in multi-media presentations for immediate student interaction, e.g. tape-slide presentation devices, closed circuit TV, overhead projectors and tape recorders in language laboratories. This overcomes the feedback shortcomings of these technologies mentioned in Sec. 3 and supplies information for its upgrading.

7. The Technologically Integrated Educational System

An idealized block diagram of such an educational computer based system is shown in Fig. 6. Several feedback loops for the teacher and the student are seen to be present. The direct information flow line between the students and the teacher during a verbal interaction carries information in both directions, e.g. in open class discussions.

Each student is provided with an input/output terminal, which must be capable of handling the alphabet, numbers and symbols, and provide him with reinforcement. The teacher can address the students directly (using his own source of information) or by means of any audio-visual device with prepared materials.

The audio-visual devices are controlled by the teacher, or at the teacher's discretion, by the computer contained within the teacher's console. These devices also transmit the encoded data (referred to earlier in this section) to the computer for immediate student interaction.

When a student responds on his terminal the teacher can simultaneously see all the relevant data on the teacher's console via the display and printer.

The teacher's console also includes a recording device (such as a magnetic disk) for lesson storage, and if necessary for recording the student responses for later analysis. After every session, reports on each student as well as on the lesson, are produced by the printer.

This integrated Cybernetic communication system

7.1 can be switched to either self-paced learning (e.g. with the aid of books, tapes or screen) or to group teaching/learning where students respond to questions posed by the teacher (with or without the help of audio-visual devices)

7.2 places no constraints on teaching methodology

7.3 constantly involves all students even in large classes

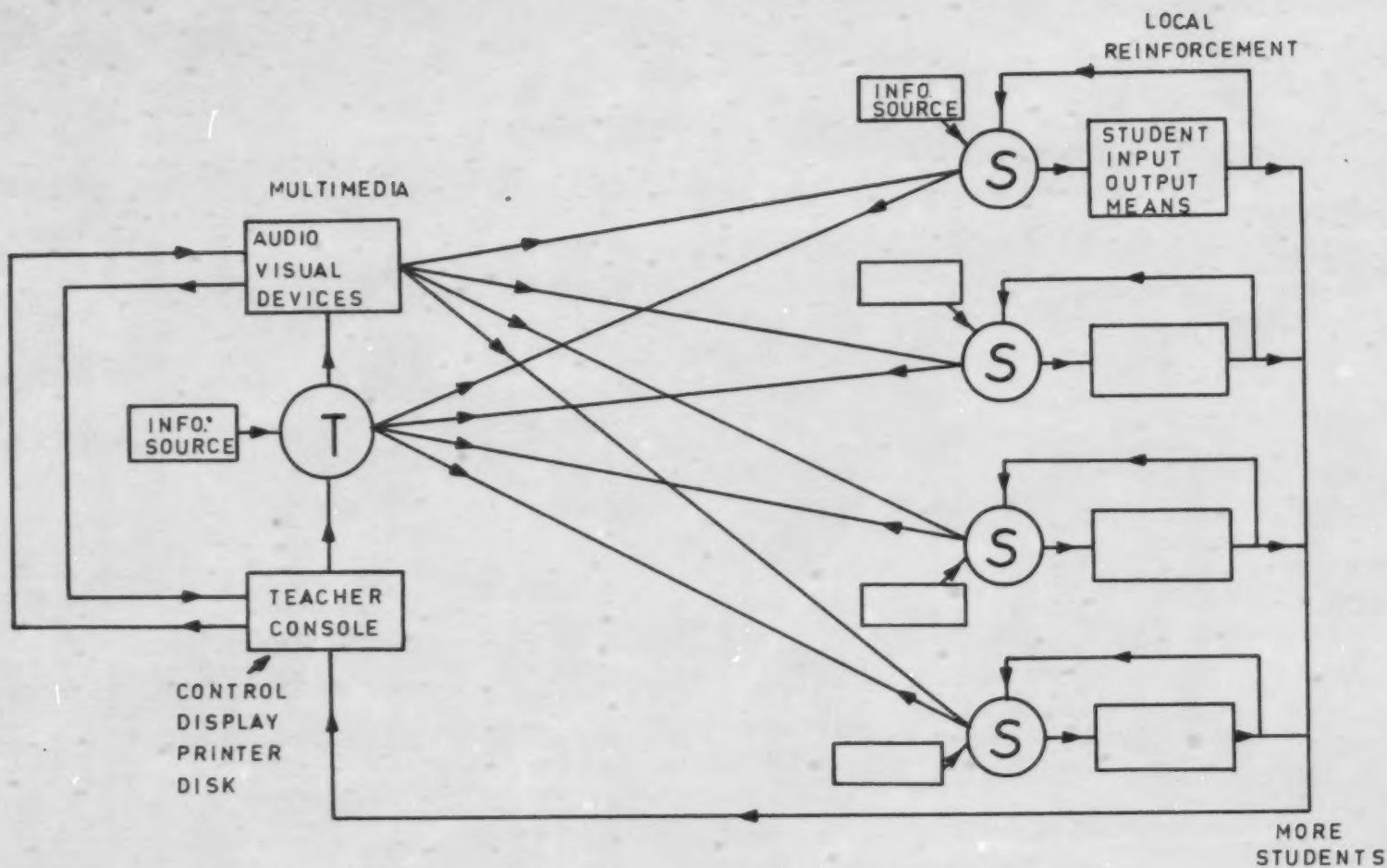


FIG 6.

7.4 can be used spontaneously as a communication system with or without courseware (on disk) and therefore need never stand idle

7.5 allows for full sentence answers thereby encouraging creativity

7.6 is not limited to teaching facts

7.7 produces immediate measurable results

7.8 is independent of the subject matter or level being taught

Provided the system is properly designed it should not require technical knowledge of computers or programming on the part of the teacher for its proper operation, in the same way as one does not have to be a motor mechanic to drive a car.

Since every student is constantly actively involved (as opposed to the situation in a conventional classroom) a system of this nature permits the use of larger classes (64 and higher).

Should the student fail to respond in a group teaching situation, or work too slowly in a self-paced situation, the teacher can immediately see it on his screen and take appropriate action.

At all times, wrong or unexpected responses, or the questions of students, are displayed or recorded so that additional explanations can be given in the group teaching mode or the material possibly altered in the future in the self-paced mode. Of course a self-paced program can be either of the linear or branch type depending on whether the intention is testing or learning.

As stated, different methodologies can easily be applied. For example a teacher may choose to present the lesson verbally; or use audio-visual devices for presentation, to be followed by personal interaction with the class; or the entire system may be placed under computer control where multi-media are used for presentation and student interaction takes place only with the computer program, or students can work at their own pace from programmed tapes or books.

The degree of automation (i.e. whether a qualified teacher, or a proctor, as theoretically no teacher at all is required) is entirely at the discretion of the course supervisor and is not dictated by the technology.

8. Quasi-Interactive Broadcast Educational Television

We believe that potentially one of the most important audio-visual aids for South Africa is Broadcast Educational Television in association with the system described in Fig. 6.

This means that during the broadcast, questions can be asked by the television teacher which each student throughout the country is required to answer, and in consequence receives suitable reinforcement or corrective comments. The local teacher, who need not be fully qualified, is also involved not only by being able to monitor the actual responses of the students, but by also receiving private tuition from the television teacher on his/her console slightly ahead of the students. For example, when a question is

asked, the local teacher is given the correct answer plus comments on possible wrong answers which the students may give. At the end of the lesson a print-out is produced indicating which students did not follow which part of the lesson so that remedial tuition can be given to those students.

This technology can now be implemented in South Africa. It is believed to be the only practicable solution to the problem of mass education at reasonable cost at this time.

Note that this technology does not require additional communication lines, e.g. telephone lines or cables. It is accomplished by encoding on the broadcast TV signal, the answer to questions (plus additional remarks for the teacher only) seconds ahead of the question being asked by the television teacher. Thus a form of Teletext technology can also be used to accomplish the encoding.

9. Conclusion

Looking back at history, we believe that the only technology in education which rivals in importance the invention of the printing press is the computer, not because of its computing power, but because of its communication ability.

The printing press answered the communication problem of the dissemination of information at low cost. Similarly the computer can help to solve another important communication problem in education by allowing many to "talk" simultaneously and be understood.

The answer to the education problem in South Africa lies in increasing the student teacher ratio through technology which permits larger classes without sacrificing the psychological benefits of student-teacher contact.

It is now up to industry to release larger blocks of workers for training or to reorganize in other ways, so that the numbers being trained become a significant portion of the work force. It is also up to the State to ensure that the broadcast and education authorities jointly examine what is technically possible and educationally desirable. South Africa can lead the way for the rest of the continent.

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THE NIPR COMPUTER-BASED PSYCHOLOGICAL TESTING SYSTEM

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ABSTRACT

The NIPR computer-administered psychological testing system, based on PLATO, is now available to test users. It overcomes many problems associated with the use of tests by providing completely standardized administration and automatic data collection. It provides the test publisher with a simple means of distributing new tests and updating existing tests and enhances the control of testing. The system contains psychometric programs for test development and evaluation and for the establishment of norms. Test quality is improved and more sophisticated types of tests can be developed. Though developed for industrial psychological testing it also has uses in education and training.

The National Institute for Personnel Research (NIPR) of the Council for Scientific and Industrial Research has recently launched a system for computer-administered psychological testing based on Control Data's PLATO. This system is designed to provide computer-based testing to test users throughout the country, not only for NIPR tests but also for the tests of other publishers and for user-constructed tests. The development of a large scale system of this kind is very costly in terms of both skilled manpower and money, and for the user of the system there is also a considerable financial outlay. Thus it would seem that some justification is needed for the creation of such a system. This justification will be shown to lie in the need to improve the quality of psychological testing, in meeting the needs of the test publisher as well as those of the test user and in maintaining high ethical standards in the use of tests. At the same time it will be apparent that psychological testing does not take place in isolation, but is closely connected with the needs of education, training and the effective utilization of manpower and that the computerization of tests can facilitate their contribution in these areas.

The limitations of psychological tests

Since the beginning of this century, psychological testing has become an increasingly useful tool for the clinician, educationalist and employer. For most people, the term *psychological test* brings to mind the intelligence or I.Q. test, but this is only one type of test amongst a wide variety of the different kinds of tests that are now regularly employed. There are tests of personality, interest, ability, attitude and of specialized skills to name only some of the most important categories.

Essentially, the standardized psychological test is a quantitative measuring instrument that measures the behaviour of the testee in a carefully defined and restricted situation, namely the testing situation. The results of the test enable the test user to make rational decisions about the testee, to predict his behaviour in other situations and, in particular, to make comparisons between testees.

Nevertheless, psychological tests are limited in important respects which have a direct bearing on their usefulness. In the first place, tests measure only those aspects of behaviour and psychological functioning that are common to all persons or to large groups of people. They do not, and indeed do not seek to measure or determine that which is unique in the individual. Further, any particular test can only measure a small area of this common behaviour. In the second place, performance on a psychological test depends not only on the attribute being measured but also on the background of the testee, on his culture and on his experience. Thus a test must be appropriate not only for what is being measured but must also be appropriate to the individual who is being tested. Finally, psychological tests are not precise, completely accurate instruments, but always contain error of measurement so that it is only possible to make probabilistic statements about the individual on the basis of test results.

In seeking to improve psychological tests and their usefulness, considerable effort is devoted to minimizing the effects of these limitations: a greater variety of tests is provided to cover more of the common aspects of behaviour; the range of tests is extended to provide appropriate tests for persons of different backgrounds; tests are improved to give smaller errors of measurement.

Although conventional tests, both of the *paper-and-pencil* and apparatus varieties, will continue to be produced and improved, it has been apparent for some time that in order to achieve major improvement in psychological testing it will be necessary to develop radical new testing techniques, techniques in which the computer will play an essential rôle.

Problems in the distribution of tests

The use of psychological tests came to the fore in South Africa with the advent of World War II and the needs of the military to select and train large numbers of recruits. An Aptitude Test Section was established in the South African Air Force and with the coming of peace this section was eventually transformed into the NIPR. Although the NIPR now carries out a wide variety of research and development in the personnel field, tests have remained one of its major products and today, together with the Institute for Psychological and Edumetric Research of the Human Sciences Research Council, it is one of the major publishers of psychological tests in the country. As a test publisher the NIPR has a responsibility not only to develop tests but also to maintain them and to ensure that they are effectively able to meet the needs of the test user. This presents a number of problems of a practical nature.

Tests, as measuring instruments, are not static. With time and the changing educational level of the groups with which they are used, the effectiveness of tests can change and it is necessary for the publisher to carry out research continually in order to ensure that the tests have not lost their effectiveness. The collection of the necessary data results in many administrative problems, especially when there are a large number of users each using a test on a small number of testees. Another problem derives from the fact that the score on a test, unlike a physical quantity such as length, does not provide an absolute scale of measurement. On their own the scores provide little more than a ranking. To provide a stronger and more useful form of measurement data is collected on *norm* groups. The distribution of the test scores for these norm groups provides a standard of comparison that enables, for example, an employer to decide whether or not to employ a given job applicant. However, for the comparison to be useful the norm group must be representative of the population of potential applicants and this means that a wide variety of norms should be available to the test users. Again the collection of data on these norm groups presents severe administrative problems for the test publisher. Where applicants have radically different backgrounds, norms are less useful and often *criterion referenced* tests are used which enable the employer to predict the level of performance or the probability of success in the job on the basis of the test scores. This presents data-collection problems at least as severe as those encountered with the establishment of norm groups. Other problems are faced by the test publisher in the distribution of new tests and in the distribution of modified versions of tests with the simultaneous withdrawal of the obsolete versions. There is also the problem of *piracy* - the illegal copying of paper-and-pencil tests which is all too easy these days.

The ethical control of psychological testing

Tests, as part of decision processes that can affect the lives and careers of individuals, are open to abuse. Where the needs of the test user are seen as being in conflict with those of society, and specifically with the needs of the testee, considerable controversy can arise about the use of tests, as has happened recently in the United States. To minimize this possibility of conflict, and to protect the person being tested, the South African Government introduced legislation as part of the Medical, Dental and Supplementary Health Service Professions Act, act 56 of 1974. Effectively, this places the control of psychological testing in the hands of registered psychologists who in turn are under the ethical supervision and control of the Professional Board for Psychology, part of the Medical and Dental Council. Matters relating to the categorizing of tests and the setting of standards for tests and their use have been delegated by regulations in terms of the above act to the Test Commission of the Republic of South Africa (TCRSA). All psychological tests fall under the overall control and supervision of psychologists and the users of tests must be persons registered with the Professional Board or the TCRSA, depending on their professional status. Action can be taken against unregistered persons using psychological tests or against registered persons who misuse tests. In practice, however, it is very difficult for the TCRSA to ensure that tests are not used by unregistered persons or for it to monitor effectively the use of tests to ensure they are not being misused.

The development of the NIPR computer-based testing system

The NIPR has for a long time been aware of the possibilities offered by the computer for the improvement of psychological testing. Computer-based testing offered the possibility of completely standardized administration, impossible to ensure in conventional individual testing, together with the flexibility that is impossible to achieve in the group testing situation. Most of the data-collection problems could be overcome with the automatic recording that computers could provide. However, early experience with general-purpose computer systems was not encouraging, largely because they were unable to guarantee response times. Thus, in the mid seventies, the NIPR developed the VALET system for computer-administered testing based on a dedicated mini-computer. This system was successfully used for research but its usefulness was limited by the need to bring the testee to the NIPR for testing and it did nothing to overcome the problems experienced by the NIPR as a test publisher. It was obvious that what was needed was a network system with terminals located where the testees were. Such a system would allow the NIPR to distribute and update its tests via the network and at the same time enable it to collect data automatically from the test users as they used the tests in practice. It would also enable the NIPR, acting on behalf of the TCRSA, to control who used tests and to monitor, more readily than was possible with conventional tests, how the tests were being used. The network would also provide a ready means of access to samples for experimental purposes.

When Control Data introduced its PLATO system into South Africa the NIPR began to consider seriously the possibility of using it as the vehicle for the NIPR testing system. At the same time, the Electricity Supply Commission (ESCOM) was evaluating the use of PLATO and began to experiment with using the system for the presentation of psychological tests. In 1980 the NIPR and ESCOM agreed to collaborate in the development of psychological testing on PLATO.

without computer administration. One new type would go beyond the usual question-and-answer format by allowing the testee to ask questions of the computer. Such a test is the proposed new version of the *in-basket* test, a test of executive decision making ability. Another new type of test that the NIPR intends introducing is the *adaptive* test. In this type of test the item given to a testee depends on his responses to previous items thus matching the difficulty of the test given to the ability of the testee. Such tests have many desirable characteristics: they measure ability to a given degree of accuracy with far fewer items than a conventional test thus allowing more facets of ability to be measured in a given time; they can cover a far wider range of ability; they are desirable from the motivational point of view as the less able testee does not become as easily discouraged; they allow far more precise discrimination between testees of similar ability.

Computer-based testing in education and training

Although the NIPR system was primarily developed for *psychological* testing it can as well be used for the other types of tests used in education and training. From the psychometric point of view, achievement tests and other types of tests used in education do not differ in principle from psychological tests. There is the same need for rigorous evaluation of the test, the same need for standardized administration, there is the same need for norms against which comparisons can be made and it is just as essential to evaluate the test against the relevant criteria. Conventional tests, whether psychological or otherwise, are already extensively used in connection with education and training. Intelligence testing is widely used, standardized scholastic achievement tests are used in many situations, tests are used to determine learning deficiencies, they are used to determine whether a potential trainee can benefit from a training course and to evaluate training courses, tests are an essential part of the vocational guidance process and tests are used in the handling of personality problems in the school situation. The availability of a computer-based testing system could facilitate the use of tests in these situations. School psychologists could readily test at schools without having to visit them and vocational guidance could be provided throughout a school system without the need for registered test users at every school. In particular, where PLATO is used for training or educational purposes, the presence of tests on the same system would lead to greater efficiency and eliminate many administrative problems.

Computer-based testing can even be used within the normal classroom situation. Simple tests, such as those of the multiple-choice type, can be used in the classroom to determine the progress of the individual pupil or student and to evaluate the need for revision or changes of emphasis in teaching. This is particularly valuable when the student-teacher ratio is high. That such tests are seldom if ever subject to any sort of psychometric evaluation is understandable since the teacher or lecturer does not have the time, the technical facilities or perhaps even the knowledge to carry it out. With a computer-based testing system that provides automatic data-collection, simple and immediate access to psychometric programs and training lessons in their use, classroom tests could easily be evaluated, the test could be improved and the teacher would get the feedback that would enable him to make better tests in future. *Driver* programs requiring only that the questions and answers be typed in at a terminal would make it simple for even the teacher with no knowledge of programming to prepare computer-based tests. Although

It is largely due to the enthusiastic collaboration offered by the Recruitment Section of ESCOM that the NIPR has been able to develop its system in a relatively short time. With the active support of Control Data the system has been developed to a stage where it can be offered to test users throughout the country. Today, more than twenty tests or test versions are complete or in the final stages of completion together with the psychometric programs need for test development and the establishment of norms.

The benefits of the computer-based testing system

It is now time to evaluate the benefits derived from the computer-based testing system, to determine to what extent it has met the problems listed above and to assess its potential for the future. It is evident that the tests currently available on the system do not represent a sufficiently wide variety to satisfy the needs of all or even of most potential test users. However, the development of new tests is an on-going process and more tests will be constructed in response to the needs of test users. Facilities have been built into the system for the automatic collection of normative data and it is possible for a user to define his own files for the collection of specialized norms. Psychometric programs are provided for the virtually instantaneous calculation of new norms which then become immediately available to the test user. Thus the administrative problems associated with the establishment of norms have been overcome. Similarly, the programs for the establishment of criterion-referenced tests, though not yet part of the system, will shortly be available and will remove the problems associated with the use of this type of test.

The problems of distribution faced by the publisher are eliminated as a new test becomes immediately available to all authorized users and any modifications to a test become immediately effective. Piracy is eliminated as tests can only be used on the system. The system has been designed specifically to meet the requirements of the TCRSA for the control of tests. Only test users who have been registered for a specific test can use that test and unregistered users are simply unable to access tests on the system without the active connivance of a registered test user. The system provides the test publisher with the means of monitoring the use of tests which, while it cannot entirely eliminate it, makes misuse of tests more difficult.

A further benefit of the system is that a test user can initiate testing at a distantly located terminal. This means, for example, that an industrial psychologist located in the central personnel department of a large organization can test job applicants at any of the organization's factories or branches wherever they might be located. Similarly, a school psychologist could simultaneously test pupils at widely scattered schools. No matter where the testing takes place, the results are immediately available to the test user for evaluation.

The full potential of the system for the development of radically new types of tests is as yet far from being realized. Most, though not all of the tests developed thus far are similar in format to conventional tests. Use has been made of the computer's capacity to provide better instructions for the tests and responses are accurately timed - experience with the VALET system suggested that the speed of response could often provide a better measure of ability than the number of correct answers. However, the NIPR is considering the development of new types of tests that could not be constructed

such a use of computer-based testing would seem to be something for the future at the primary and secondary levels, it could even now prove of benefit in tertiary education and especially in high cost industrial training situations.

Evaluation of the current status of the NIPR system and its usefulness

The NIPR computer-based testing system, which is - as far as is known - the first large scale system of its type in the world, currently offers users improved quality of testing together with ease of administration. The number of tests available at present is limited but this will grow steadily. It is still a relatively expensive way of testing, though this is likely to decrease as the cost of computing continues to drop, but even now it can, in particular circumstances, not only be justified financially but can result in considerable savings. Its usefulness is enhanced when PLATO is also used for related purposes such as education and training or personnel administration with which it can easily be integrated. In the industrial and commercial sector it is likely to be of immediate benefit to large organizations with distributed testing needs and to organizations where testing is carried out by outside consultants. In the educational sector it could be used with effect in tertiary education for psychological and guidance related purposes and could readily be adapted to more general edumetric uses. At the primary and secondary educational levels it could be used in the school psychological and vocational guidance services. As the relative cost of computer-based testing drops and more powerful tests become available only in computer-administered form, the NIPR system and others like it will become the primary means of psychological and related types of testing but it will be a long time before the conventional non-computer test vanishes.

OPERATIONAL STANDARDS IN COMPUTER-ASSISTED INSTRUCTION

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ABSTRACT

CAI was introduced some twenty years ago and, in many ways, has been a disappointment; exaggerated expectations of the capabilities of technology were compounded with misunderstanding and even abuse of the medium. Only two of the major innovations of the 1970's have evolved to make lasting contributions; these are PLATO (University of Illinois and CDC) and TICCIT (Mitre Corp).

The microcomputer, in its guise as a personal computer (and contrasted with the "impersonal" main-frame), provides a new opportunity and new challenge. It behoves the innovator to learn from past errors and make the most of the new, wider opportunities afforded him. In order to do this he must respect the medium and take account not only of the conceptual but also of the human requirements of the user.

The user interacts with the system via the screen and the keyboard. The screen must display information clearly and cleanly, ask questions explicitly, and avoid display of mysterious systems messages - the user must be assumed to be computer illiterate. Keyboard response must be rapid, entry requirements must be unambiguous, and mistaken entries should be elegantly handled, so as not to obtrude on the user. All of these requirements place severe demands on the care and imagination of the author and programmer.

A manual of standards for operations has been prepared, with particular reference to the capabilities of the Apple microcomputer. The manual will be made available, and the applicability of its features discussed.

Introduction

In its short lifetime, CAI has had a disappointing history of high hopes and comparative failure. We may trace the sources of this failure to the programmed learning books of the late 50's and early 60's, together with the learning machines which developed to mechanise the process of application thereof. The principles applicable to such systems of limited sophistication were often simply transferred to the newly-available computer, which was made to emulate its nearest ancestors, acting as an expensive "page-turner" having minimal interaction with the user. Thus, there would be much text, scrolling repeatedly up the screen to the annoyance and frustration of the user. Individualised interaction would be of limited extent, the user simply proceeding in a linear fashion through the proffered material. There were also the frustrations of time-sharing systems: frequent system crashes, and slow, unpredictable, response rates.

Of the many large systems running CAI, only two have recieved wide acceptance; these are PLATO, which was developed at the University of Illinois and is now available in South Africa, and TICCIT, which provides industrial training in the main, and is not known locally. Such systems are expensive, running on dedicated computers in order to provide acceptable response times and full learning management facilities. They can only survive by virtue of the economies of scale. However, the recent development of personal computers has put a new complexion on the situation; the complexion is, indeed, very new because the first of the personal computers (Altair) was produced only in 1975, in a very rudimentary form suitable only for those with the time and inclination to remedy the design faults of the system. There has been a tremendous development of these microcomputers in the ensuing years, to increasingly sophisticated levels, some of the systems providing facilities which are unusual in even the most developed of main-frame computers, such as: interactive colour graphics (operating in real time); sound and speech; control of external devices such as slide projectors, video players and, most recently and portentously, video-disc players.

Early uses of the personal computers were discovered by hobbyists and enthusiasts exploring the capabilities of their new toys. Subsequent acceptance into the home and business has been shown by the development of numerous games, word-processor packages, data-base systems, and accounting packages of various degrees of sophistication.

Acceptance, as serious devices, by educators has been a little slower, but the accolade was, perhaps, given in 1981 by CONDUIT, a major distributor of educational software suitable for a range of machines (by virtue of being written in a "transportable" dialect of BASIC). The decision was to select three microcomputers for which it would act as distributor, these being the Apple II, Commodore PET, and Radio Shack TRS-80.

At the University of Witwatersrand, it was decided in late 1980 to develop a system of computer-assisted instruction in Chemistry for a group of students in need of academic support, starting in 1981. Use of the PLATO facilities already locally available was carefully considered and, indeed, arrangements were made for a terminal to be used on a trial basis. However, the exceedingly high cost to us of PLATO, coupled with the only partial suitability of the available teaching material forced a reconsideration of the alternatives. We had already had a few months experience of using Apple II microcomputers in the physical chemistry laboratory, where we had found its features to be impressive. We were confident of our ability to program material, and the acceptance of the Apple II in educational circles overseas led us to believe that software would increasingly become available to us. Nevertheless, we would be early starters in the field, the software of which we knew was poor in the extreme, and the Apple had certain major deficiencies, of which the principal one was an inability to enter lower-case characters from the keyboard, together with an inability to display lower-case on the normal text screen; it is known [1] that the legibility of text suffers when presented in upper case.

Faced with this only partially satisfactory situation (a curate's egg, if ever there was one), but blessed with a group of knowledgeable enthusiasts, we determined to proceed. Now, barely a year after we started, we have a suite of some 55 operational programs in Chemistry for the use of the Apple II, many purchased, but not one unadapted to some lesser or greater extent. In fact, some of the adapted programs are being repurchased from us by the original vendors, for distribution worldwide. By the end of the first year of our CAI operation, our various programs had been run by students over 8 000 times.

It is on the basis of this experience, as well as what we have culled from the literature, that we wish to relate our present appreciation of appropriate operational standards for CAI. For these purposes, we take "operational standards" to represent the level of care taken in : presentation of material to the student; protection of the computer-illiterate student from the operating system of the microcomputer; and recording of student success (or otherwise) in his progress

through the material. We have not always managed to reach the standards which we have set for ourselves and, indeed, we are continually raising those standards. But, by setting our aim high we have managed to attain a successful, working operation in the briefest conceivable time.

In order to implement standards, it is necessary to consider the facilities available, and we will examine these seriatim, following the sequence used by Nievergelt [2]. The ideas presented are general, but we will occasionally refer to particular implementations on the Apple, both because this reflects our experience and because it provides a suitable exemplification of the point under discussion.

Hardware

It is sometimes suggested that the program material is of prime importance, and that the hardware should take a second place. In our view, this is too weak a position to take. If the hardware cannot perform the functions required of it, then the software will never get a fair chance to show its paces.

The requirements of the hardware and system software are that:

there must be sufficient user memory (the Apple is supplied with 16 kbytes but can be enhanced to 48 kb; with the low cost of memory today, we regard this enhancement as mandatory;

response must be rapid (a time-sharing system can introduce delays of seconds, which the user will find obtrusive if delays arise even for trivial requests - delays of even one-tenth of a second will be obtrusive if the request is simply for the presentation of the next portion of text, or a response to a multiple choice question);

rapid access to programs and program material is important (we would not consider using cassette-storage for this reason - floppy disks are adequate but hard disks would be better);

the terminal display must be clear, steady, and flicker-free (we now prefer green screens, but have no objections to good black-and-white);

the screen should display text of some 20 lines of characters each (the Apple is deficient in having 24 lines, only 40 characters wide);

all normal characters should be available, including upper- and lower-case, and in the scientific disciplines it is necessary to have sub- and superscripts, as well as special characters such as Greek letters, mathematical symbols, and so on (no system has this capability without user-defined characters - the Apple is seriously deficient in its hardware display capabilities but, fortunately, it has exceptional software for the creation and display of essentially any characters, so that this apparent deficiency has become something of a boon);

graphics is a necessity, not a virtue - and the display should be on a raster, with random access write/erase capability, of at least 200 by 200 points (medium resolution - but called high resolution by the manufacturers of microcomputers, to contrast with the low-resolution, text-adapted, graphics mode of some 30 by 40 points). In our view, many popular microcomputers should be discarded from consideration for scientific CAI solely on the grounds of their lack of at least medium-resolution graphics.

Author Language

Our experience has been that BASIC, with its string-handling capabilities, with PEEKs and POKEs to alter internal switches and states, with adequate (if limited) input/output facilities, serves well as the medium for programming. We have examined a couple of author languages (in particular, PILOT) and have found them to be slow and inconvenient. In this we have support from Nievergelt [2] who suggests that "an author of CAI material will not be satisfied with the programmed-instructional-type author languages on the market. He will prefer any conventional high-level programming language which is suitable for writing interactive programs". We have also considered PASCAL, but its non-interpretive character and heavy recourse to the disk on the Apple make it an unattractive medium for our present programming needs.

Courseware

"Today it makes no sense to start a CAI project unless one is willing to write most of the necessary software" [2]. When we started, there were only two significant commercial offerings of Chemistry CAI for the Apple - with some 50 programs in all. We bought all of this, and whatever else we could lay our hands on. We were distressed at the poor quality of the offerings - largely in respect of screen display characteristics, such as chemical symbols all in upper-case (H_2SO_4 or, worse still, $NaCl$), but also with regard to the careless chemistry: incorrect nomenclature; no SI units; factual errors. This poor situation was compounded by the lack of clear instructions, at times leaving one with no option but to press the RESET button to remove oneself from a CAI cul-de-sac. Hence, we determined to demand the following as our minimum operational standards for a CAI lesson (many of these are beautifully illustrated in a program on Style by Nievergelt [3], on the PLATO system):

- | | |
|----------------------|--|
| Scrolling | The screen must appear as a page to the user, turning at his command. Questions must remain locked onto the screen until no longer needed. Random key-presses should not allow the requisite information to disappear. |
| Timed Loops | Displays should (at most times) be under the user's control so that he can dismiss one display and proceed to the next at his leisure. Nothing is more annoying than a display which disappears before it can be read and understood; only slightly less undesirable is the display that pauses without apparent end. |
| Program Robustness | The program must yield appropriate responses to all possible user entries, for example, a null entry (simply pressing the RETURN key), or multiple null entries (the keyboard buffer should be cleared before each new INPUT). The program should also be able to handle lengthy responses, excessive use of the erase key, incorrect response types (eg., alphabetic for numeric, and vice versa), and multiple incorrect responses. |
| Program Friendliness | The program should be able to handle equivalent correct responses (eg., two or 2) and check input for range. |

On demand it should provide HELP; return to a previous step; or allow the user to escape (either from the present question or the whole program).

Program
Detailing

The program must make the user's task as easy as possible, by being as unobtrusive as possible. Screens should be clearly laid out; options should be clearly put (in tabular form, rather than within sentences); questions should not be coded (eg., Yes = 1, No = 2); unnecessary abbreviations should be avoided; grammar, punctuation, spacing must be correct; plural forms must be correctly handled (eg., avoid printing "1 moles of hydrogen"); graphics and sound must be used appropriately and sparingly. There should be no long stretches of text with minimal user intervention - the virtue of CAI is its interaction with the student; that virtue must be exploited.

Invisible
Functions

The program must keep appropriate records, including comments from users. There should be a way for a user to leave a lesson and, later, rapidly return to the same point in the lesson (often implemented by means of menus).

Transporta-
bility

There is considerable demand for portability of programs, so that a program written for one machine may be used on another. There is good reason for this on a main-frame computer, when facilities from one computer to the next one are largely the same, so that portability eases the introduction of programs at other sites. However, the features of one microcomputer are sufficiently different from those of the next that to limit the features used, in order to enhance portability, can so degrade performance as to be a misuse of the system under consideration. For example, the Apple without its graphics is a poor thing indeed. Of course, it would be appropriate to strive for portability in some mathematical analysis, say, or in some generalised procedure; but CAI does not fall into that category. L.E. Frenzel [4] has written that "maximum portability usually compromises the end product in some way. But the result - greater software availability - may be worth it." So far as this refers to system-enhanced CAI (and the statement appears in this context), we will reject the proposition.

Postscript

We have mentioned a number of the directions in which we have set ourselves standards, and we believe that this conscious attempt to meet our prescriptions has resulted in programs of which the more recent (at least) are interesting to the student, and unobtrusive in operation.

It is, perhaps, also appropriate to mention a few aspects of our CAI operation to which we have not paid any special attention, and where we are conscious of some glaring deficiencies. Firstly, our program design has been of the most rudimentary order, with essentially linear progressions through material (and, of course, asides for help and advice to the student). We have not implemented any firm procedures by which incorrect responses are analysed and appropriate remedial action taken by transfer to a different program sequence.

Even with exhortations ringing in our ears to plan "top down", to program "bottom up", and to use modular structures, we have actually paid little attention to programming style. Our main concern has been to get robust, working programs. As a result, our work is poorly commented and totally undocumented, lines are numbered in ragged sequences, concatenated into arbitrary groupings, and routines have multiple entry and exit points. The results are not quite as unfortunate as the above list of faults might suggest, for the very linearity of our programming renders analysis quite tractable. We believe that there are few instances of indecipherable code, except for the inevitable sets of POKEs and PEEKs required by the operating system. However, a programmer unfamiliar with our procedures and without the special editing tools to which we have access would make heavy weather of any marked modification to our programs. In our own defence, we should also mention that we have put together a number of routines which are regularly included in our programs; for example, a lower-case entry, name and chemical formula display, and a generalised multiple-choice program.

A glaring deficiency in our system is that we have not implemented any proper method of assessment and feedback; our judgements are largely subjective and anecdotal. What we would wish to do, given the time and the staff, is to set up a system such as suggested by McKenzie *et al* [5] where staff members observe (without comment) novice users as they progress through programs. Problems and ambiguities are then noted and the user quizzed on his reactions to the material which has been presented to him. The results of such surveys should then be utilized to improve programs and procedures.

We have of course, done this on an informal basis, but much more attention is required.

In spite of the above strictures, the period during which we have implemented CAI has been interesting, rewarding, and even exciting. The opportunity to work closely with student programmers has been a stimulus to our own thinking; the opportunity to work in a field of new educational technology has widened our horizons and opened our minds to the many further technologies which will soon become available to us [6].

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ASSURING COURSEWARE QUALITY THROUGH SYSTEMATIC DEVELOPMENT AND EVALUATION

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ABSTRACT

If the great potential of Computer-Based Education (CBE) is to be realised, both the developers and users of CBE curricula must stress the importance of quality in the instructional materials that are produced. Adequate hardware and software features are essential, but it is the instructional effectiveness of the courseware that will determine whether CBE can solve a particular education or training problem. Effectiveness must be built into materials during their development. This can be accomplished through careful execution of a systematic development approach. Appropriate evaluation techniques should be applied to verify courseware effectiveness. This paper discusses both systematic development and evaluation.

INTRODUCTION

Quality and Effectiveness in Computer-Based Materials

If the great potential of Computer-Based Education (CBE) is to be realised, both the developers and users of CBE curricula must stress the importance of quality in the instructional materials that are produced.

Continuing advances in computer hardware and software technology have enriched the capabilities of the CBE medium to a very impressive state, and we can expect further enhancements in the future. However, dazzling hardware and powerful authoring languages are not sufficient to guarantee increased levels of education and sharpened job skills. These benefits will be realised only when large amounts of relevant, appropriate, high-quality instructional materials have been developed, tested, and properly implemented. Educators should not lose sight of the fundamental importance of quality and effectiveness in the CBE materials to be used by their students.

Simply being delivered by a computer doesn't automatically make CBE curricula effective. Their effectiveness (or ineffectiveness) derives from :

1. the degree of care taken by the developing organisation in design, development and evaluation, and
2. the level of effort spent by the using organisation in selection and implementation.

Both the developer and the user contribute to the ultimate effectiveness of computer-based materials for any particular group of students.

Importance of Quality Assurance and Evaluation Processes

The likelihood that a computer-based curriculum will be successful is greatly increased when a systematic, phase-by-phase approach to development is followed. [1] Focusing in turn on the requirements of each phase enables the developing organisation to apply appropriate quality assurance measures at each step. Effectiveness of CBE materials cannot be left to chance -- it must be "built in" through all phases of development.

Neither can it be assumed that a systematic development approach is sufficient to establish effectiveness. The effectiveness of materials must be assessed through appropriate evaluation techniques.

This paper outlines quality assurance procedures that can be applied by developers of CBE curricula within a systematic approach to development. It also discusses techniques of formative evaluation (done by or for the developing organisation for the purpose of curriculum improvement) and summative evaluation (done by the publishing organisation or the user for the purpose of determining the effectiveness of a curriculum in meeting its goals). Finally, it describes the role of the using organisation in contributing to the effectiveness of computer-based education and training.

The paper takes the view that systematic development, careful evaluation, and proper implementation are all essential in assuring that the potential of CBE is realised.

QUALITY ASSURANCE THROUGH A SYSTEMATIC DEVELOPMENT PROCESS

There have been numerous models proposed for the systematic development of instructional materials. Among the most widely known is the Interservice Procedures for Instructional Systems Design (IPISD) prepared by Branson and his colleagues [2].

Another model, written specifically to guide the development of computer-based curricula [3], is illustrated in figure 1. It divides the overall process into a sequence of six major phases.

- Analysis
- Design
- Development
- Evaluation, Part I (Formative)
- Implementation
- Evaluation, Part II (Summative)

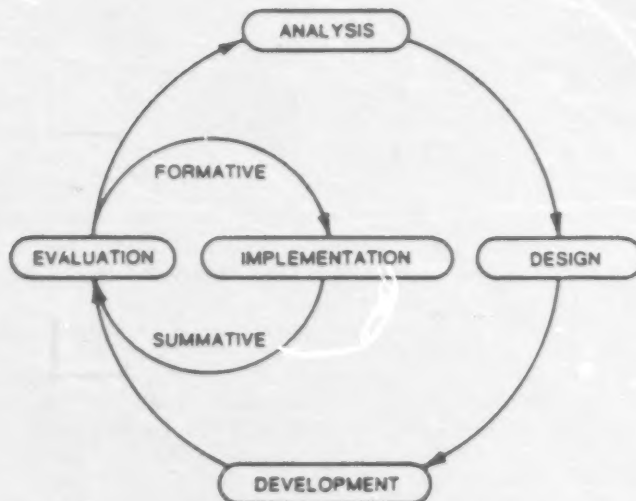


Figure 1. The development process

The following sections summarise the primary activities in each phase and highlight the quality assurance steps that should be taken. The sections on formative and summative evaluation also describe commonly-used evaluation techniques. For further explication of the model see [1] and [3]. Examples of its application to CBE development projects are given in [4] and [5].

For the purposes of the discussion it is useful to define what is meant by the following terms :

- Courseware - a generic term for computer-based lessons, courses, or curricula. It also includes any materials from other media (e.g., text readings, audio-visual materials) which are an integral part of the computer-based curricula.
- Developer/
Developing
Organisation - The team (or the individual) responsible for designing and developing courseware. The developing organisation may or may not be in the same company or institution as the customer, the user, or the publishing organisation.
- Customer - The person or organisation which commissions the development of courseware. The customer may be the organisation with a problem which the courseware is intended to solve, or it may be a representative of a publishing organisation which wishes to acquire courseware for sale to one or more using organisations.
- User/Using
Organisation - The organisation which uses courseware in hopes of solving a problem. The user may or may not be the customer who commissioned development of the courseware.
- Publishing ,
Organisation - The company or institution responsible for sale or distribution of courseware to a number of using organisations. The publishing organisation may or may not be part of the same company or institution as the developing organisation.

Analysis Phase

Prior to undertaking any courseware development effort, a needs analysis should be conducted. The purpose of a needs analysis is to identify problems in a system, analyse the potential causes of each problem, identify the most probable cause, and propose a solution which deals with the root of the problem.

Of course, not all problems are caused by inadequate training or education. Some may be rooted in a lack of tools, inadequate or malfunctioning equipment, poorly-planned procedures, or such human factors as fatigue or lack of motivation. If these or similar non-training issues are believed to be the cause of a problem, the solution should be found by addressing them directly with appropriate measures.

It would be a mistake to assume that every performance discrepancy is a training problem or that training, let alone computer-based training, is the solution to every shortfall in performance!

Nevertheless, a great many problems in business, industry, and society at large can be rectified through effective training and education programs, and computer-based curricula may be very helpful in solving these problems.

Therefore, the purposes of the analysis phase are :

1. To conduct a needs analysis of the system in question (or verify the findings of a prior needs analysis).
2. To verify that CBE can help to solve the problem.
3. To determine the requirements the courseware must satisfy, and
4. To establish the schedule, budget, and delivery constraints within which the CBE solution must be developed.

Quality assurance (QA) during the analysis phase amounts to the developing organisation's making sure that all four of these purposes are fulfilled and that they are completely and properly executed. Specific process and QA steps include :

1. Assisting the customer in completing a standard questionnaire designed to help him or her clarify the problem and establish parameters for the required courseware solution.
2. Following up with a standard structured interview to verify details.
3. Preparing a design requirements document that summarises the developing organisation's understanding of the problem, the basic structure of the solution, and estimated costs for development.
4. Obtaining approval of the development organisation's management for the design requirements document (granted upon verification of compliance with the standard for such documents and review of the cost estimates), and
5. Obtaining customer approval of the proposed technical solution (i.e., the structure of the courseware) and cost estimates.

Careful implementation of these QA steps can assure that the project is on solid footing. A thorough understanding of the problem is the foundation on which effective courseware is built.

Design Phase

The first major purpose of the design phase is to establish design specifications for the courseware. These specifications must be consistent with the requirements and constraints established during analysis and consistent with current standards for CBE products.

Above all, the design specifications must provide sufficient detail and interpretation to guide development of the various components of the course or curriculum. See [3], [4], [5], and [6] for further details on the content of design specifications documents.

The second major purpose of the design phase is to establish a comprehensive development plan. This will include a budget for developing each of the course components, conducting appropriate formative evaluations, completing revisions, and preparing masters for reproduction. It will also include a schedule for completing each major milestone and ultimate delivery to the customer. Finally, it will include an identification of the kinds and numbers of instructional developers, programmers, and other personnel who will form the development team. Establishment of the budget, schedule, and composition of the team are all based on a thorough analysis of the design specifications document.

Quality assurance procedures appropriate for the design phase include :

1. Review and approval of the design specifications document by the development organisation's management (approval granted upon verification of compliance with the organisation's standard for design specifications).
2. Management approval of budget and schedule.
3. Customer approval of design specifications (may include approval by Subject Matter Expert), and
4. Customer approval of budget and schedule.

A well-executed design phase is essential in planning CBE development projects. Adequacy of the design specification and development plan can be assured through careful execution and QA review.

Development Phase

With an approved design specification and development plan in hand, the individuals assigned to the project team are ready to commence development of the various courseware components. These include the computer-assisted instruction lessons, text readings, audio-visual materials, student manuals, study guides, test questions, and strategies for computer-management of instruction which have been outlined during the design phase. Attention must also be paid to preparation of administration guides which will aid the using organisation in implementation.

Because specifications for all components have already been prepared, several components can be developed simultaneously by the project team. There is, however, a practical limit to the number of individuals involved, and it is usually determined by the rate with which suitable content can be gathered from the Subject Matter Expert (SME).

There are five major areas of concern in managing the development process.

These are listed below together with suggested process and QA steps for assuring adequate attention to each area :

1. Assure adherence to design specifications. This concern can be met by discussing the requirements and specifications among the development team, requiring regular team meetings to review progress and discuss problems, and requiring each developed activity to be approved by the team leader (normally this is the person who prepared the design specifications).
2. Assure correctness of subject matter content. This area can be managed by requiring SME participation in and approval of content selection and by requiring SME approval of the developed activities. Further protection from content errors is provided by utilising a second, independent SME in a quality assurance role (i.e., a QA SME).
3. Assure adherence to product standards. Not only must the product meet the customer's requirements, it must meet the standards of the developing and publishing organisations. This can be accomplished by applying the relevant standards for each courseware component, applying the technical and mechanical standards established by the publishing organisation, and applying the publisher's legal standards. These standards may be applied by a range of individuals, including checklist reviews by independent developers and programmers for instructional and programming issues, edits by editorial staff, and legal reviews by legal department staff.
4. Assure adherence to project budget and schedule. This requires budgeting the number of labour hours allotted to each development activity and setting milestone dates for their completion. In addition, it requires regular reporting of time spent and completion status of each activity. When slippages occur, the team leader and the individual involved can assess the problem and work out a solution which minimises impact on the overall budget and schedule. Cost and date of availability are often the two most important criteria of quality in a courseware development project, and it is essential that these elements be properly managed.
5. Assure customer involvement in the development process. This helps maintain good working relations with the customer and fosters understanding of both the product and the process used to develop it. It is also important for keeping abreast of changes in customer requirements (but beware of the potential for costly changes of scope!). Customer involvement can be maintained through requiring the development team to make regular reports of progress and problems.

The development phase is typically the most lengthy and costly aspect of the courseware development process. Appropriate QA measures assure that adequate quality and effectiveness are built into the product.

Formative Evaluation Phase

Formative evaluation in this context is an evaluation of a newly-developed courseware product which is conducted by or for the developing organisation.

Its purposes are to assist the development team in identifying areas needing revision and, secondarily, to give a preliminary indication of the courseware's effectiveness. See [7] for background on the concepts of formative and summative evaluation.

Implementing formative evaluation. Formative evaluation is usually not undertaken until all the components of a particular courseware product have been developed and the associated QA steps have been applied. However, it is assumed that a revision cycle is part of the formative evaluation phase so that the courseware will benefit from at least one tryout and revision prior to being delivered to the customer.

The following QA steps will help assure the full benefits of the formative evaluation phase.

1. Apply the developing organisation's formative evaluation process standard. This standard should verify the readiness of the newly-developed product for evaluation and guide the evaluator in preparing instruments and materials. Adherence to the standard will assure that appropriate response and observation data are gathered and that their interpretation will be meaningful to the development team.
2. Apply the developing organisation's formative evaluation report standard. This standard should provide guidance on how the evaluator should report his or her findings and recommendations for improvement.
3. Apply the developing organisation's revisions procedure. This procedure should specify how the development team must respond to the evaluator's findings. Typically, the team (in consultation with the customer) will consider all observations and recommendations, comment on their validity, and establish priorities for corrective action. The revisions procedure should also address the need for a revisions budget so funds will be available to make the needed changes. Such a budget should be established within the development plan.

A properly-managed formative evaluation phase can be very important in assuring the effectiveness of the final courseware product. The developing organisation has made many assumptions in choosing instructional approaches believed to be effective with the target population. It should take every advantage of the opportunity afforded by formative evaluation to test these assumptions.

Techniques of formative evaluation. This section outlines three basic techniques for formative evaluations of courseware -- individual student reviews, small group pilots, and technical instructional inspections.

An individual student review involves one observer and one student from the intended audience. This technique is often called a "one-on-one."

Its purposes are to verify the completeness and continuity of the materials and assess the adequacy of directions; to assess the ease of use, effectiveness of instruction, and appropriateness of the tests; and to assess the overall student acceptance of the product.

An individual student review is relatively inexpensive to conduct, but it may not provide sufficient data on which to base revisions.

A small group pilot test is similar to an individual student review in purpose and method but it is done on a larger scale. It typically involves one trained evaluator monitoring between 10 and 30 students. The larger sample size assures that all likely paths through the materials are tested. It also allows for empirical analyses of on-line interactions and test item responses. Small group pilots are sometimes difficult to arrange because of the increased scheduling and logistics required.

A third commonly-used technique is the technical instructional inspection. It is implemented by a trained, independent evaluator who reviews the design specification and all draft course materials -- the latter in both "author mode" and "student mode." The author mode review provides an assessment of completeness and continuity of option settings and linkage among courseware components. The student mode review examines adequacy of directions, flow between instructional activities, consistency of details, apparent gaps in instruction, clarity of instruction, validity of instruction and test items with respect to the stated objectives, and assesses how well the courseware meets the design requirements.

A technical instructional inspection is complementary to student-based evaluations in that it addresses some quality issues that are not apparent to students. Furthermore, a trained evaluator is more likely to find and report weaknesses than are novice students. On the other hand, no empirical analyses of student data are provided.

All three of these techniques are valuable and, where possible, all should be applied. When forced to choose between an individual student review and a well-run technical product inspection, the development group should give serious consideration to the latter.

Implementation Phase

The implementation phase involves familiarisation of the using organisation with the materials and implementation requirements of a particular courseware product, and most importantly, use of the courseware by the intended audience.

There are important QA responsibilities in this phase for both the developing and using organisations.

The developing organisation should :

1. Apply its standard for administration guides in preparing the guide for this product.

This would normally be done during the development phase, but its importance is realised during implementation. Unless the administration guide is clear and complete, the user will be unable to implement the courseware properly.

2. Provide training and/or training materials in use of the CBE hardware and software required by the courseware product. This is a general responsibility that cuts across all items of courseware to be delivered on a particular CBE system.

Unless the developing or publishing organisation assures that the user is proficient in using the CBE system, the courseware may never be properly delivered to the intended audience and the problem for which it was designed may never be solved.

The using organisation also has responsibilities to guarantee an effective implementation. The user should :

1. Assure that all necessary facilities, equipment, and materials are available for student use.
2. Assure that implementors of CBE curricula are trained and available.
3. Assure that the implementation requirements spelled out by the developer are followed as closely as possible.

Unless the implementation phase is handled properly, the effectiveness built in by the developer will not be realised. Both the CBE developer and the user have responsibility in assuring proper implementation.

Summative Evaluation Phase

The summative evaluation phase serves several purposes. Such evaluations can :

1. Determine how well the CBE materials satisfy the original design requirements.
2. Provide a basis for decisions about continued or expanded use of the curriculum.
3. Serve as input to a subsequent analysis phase for decisions about maintenance, revisions, re-development, or development of follow-on courseware,
4. Provide feedback to the development team about the effectiveness of techniques of instruction and programming. This assists team members in upgrading their skills for future projects.

Implementing summative evaluations. The summative evaluation phase follows (or coincides with) the implementation of the courseware by the using organisation(s). It follows completion of the development project (in fact, the development team members have probably been re-assigned to other projects).

The implementation of the summative evaluation phase, therefore, is the responsibility of the publishing organisation and/or the using organisation. It is NOT the responsibility of the development team.

The following QA steps may help assure full benefit from summative evaluations of curricula :

1. Select a competent and independent evaluator. The purpose of a summative evaluation exercise is to determine the overall effectiveness of a courseware product.

Depending on the outcome, several important decisions may be taken. The publishing organisation may, for example, decide to withdraw the curriculum pending another cycle through the analysis, design, development, and formative evaluation phases. Alternatively, the curriculum may prove so successful that greatly expanded use may be warranted. In any event, it is essential that the person conducting the summative evaluation has a high degree of competence and integrity. The objectivity of the evaluation can be preserved by selecting an evaluator who is independent of the developing and publishing organisations.

2. Have the summative evaluation report reviewed by the developing organisation and by another independent evaluator. Seeking comments from the developer may help prevent erroneous decisions based on mis-interpretation of instructional intent or failure to attend to important details. Seeking an independent audit of the evaluation gives a stronger basis for decisions about the courseware product and about the original evaluation.

Summative evaluation can provide important input for decisions about sale or use of CBE curricula. However, for this input to be most useful, the suggested QA steps should be followed.

Techniques of summative evaluation. This section outlines three basic techniques for summative evaluations of courseware -- peer reviews, field tests, and user comments.

A peer review involves the careful analysis of all materials in a completed courseware product by one or more recognised experts in the subject matter field. Its purpose is to obtain independent, expert judgments as to content accuracy, presentation adequacy, and likely effectiveness with defined audiences. A peer review can help the publishing and/or using organisation prevent costly errors in publication or purchase, and it can provide valuable advice in marketing or implementation.

Field testing of completed materials involves usage by members of the intended audience under realistic conditions at one or more field locations. Such evaluations are conducted by trained evaluators under sponsorship of the publishing organisation, the using organisation, or both. The techniques of observation, achievement testing, attitude surveys, follow-up surveys and interviews, and analysis of on-line data can all be used.

An important source of information for the publishing organisation is the written comments made by students while studying the materials. These could take the form of notes written on the CBE system (feasible for network-based systems) or comments passed along in paper and pencil mode.

Regular examination of user feedback allows the publisher to identify and correct errors not found during quality assurance and formative evaluation stages. However, it would be a mistake to depend entirely on user feedback as a source of summative evaluation data because it is not systematic (not all issues are examined or commented by users).

The combination of summative evaluation techniques to be used will vary from one situation to another, but whatever approach is followed should be carefully executed.

ROLE OF THE USER IN EVALUATING CBE CURRICULA

The paper's focus up to this point has been on the roles and responsibilities of the developing and publishing organisations in assuring quality and effectiveness of CBE curricula. It is important to observe that the user also has an important role to fulfill in this regard.

A using organisation that is considering acquiring either published or custom-developed materials should query the quality assurance and formative evaluation methods applied by the developing organisation and the maintenance methods used by the publisher. As a result of this enquiry, the prospective user should be satisfied that the developer has a high commitment to courseware quality and that adequate quality assurance, evaluation, and maintenance procedures have been or will be applied to the specific curricula under consideration. The consumer of courseware, like any other consumer, must be cautious of the products or services he buys!

A major way a using organisation can contribute to the effectiveness of computer-based curricula is by insisting upon a high standard of quality assurance in the development process. Here are some further ways :

1. By participating closely in the development process (if the user is also the customer),
2. By cooperating with the developer in conducting formative evaluations.
3. By participating in or conducting field studies of completed courseware.
4. By providing detailed feedback about the effectiveness of CBE curricula as used by that organisation.
5. By providing detailed user comments about errors, need for updating, and cultural factors, and
6. By being committed to provide all support required for proper implementation.

SUMMARY

The following items summarise the major points presented in this paper :

1. Adequate hardware and software features of CBE systems are essential but they are not the central issue of CBE effectiveness -- the central issue is the quality and instructional effectiveness of the courseware.

2. Careful development and evaluation are basic to courseware effectiveness and should be stressed by both development and using organisations.
3. A systematic development process, including appropriate quality assurance steps, helps developers build in the required level of effectiveness.
4. Various techniques of formative evaluation are available. The selection of which should be used depends on the time and budget constraints in effect.
5. Summative evaluation can prevent erroneous decisions about publishing or acquiring courseware.
6. Developing organisations and using organisations have common interests in assuring the effectiveness of computer-based curricula and each has an important role to play.
7. Prospective users of CBE should satisfy themselves as to the soundness of quality assurance and evaluation procedures used by the developer in preparing a courseware product.

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SMALL TOWN COMPUTER STUDIES WITH MICROS

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ABSTRACT

This paper will be based on the presentation of courses and workshops in Computer Studies and Computer Orientation in a small town by an "outside" organisation.

Firstly it will cover the history of how it all began due to the demand and potential for such courses, and because of the number of talented and interested pupils attending the very good schools in King William's Town. How the Kaffrarian Museum became involved in offering this very valuable service is a point that is interesting and could promote similar projects, emanating from other Museums or Education Institutions.

From there the paper will cover the basis of the courses that we have run and are running. The equipment that is available to us and the reasons for our choice of using micro computers for training could very well lead to interesting discussions and innovations during the conference. Obviously we have had problems as well as our fair share of success and with some 338 students and adults having been involved in various courses and workshops, it is felt that sharing these positive and negative aspects with other delegates could lead to discussion beneficial to all.

The importance of the liaison, guidance and support received from Rhodes University, and their involvement in the project run by the Kaffrarian Museum in King William's Town will be covered fully, as will the liaison with the schools.

The final section of the paper will deal with our projected plans for the future and the importance of continued support from educational bodies. Guidance and assistance in obtaining recognition by the Provincial Authorities will be called for and constructive discussion will be welcomed.

PIC AND MICROCOMPUTER-BASED COMMUNICATION

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ABSTRACT

The Pictogram Ideogram Communication (PIC) system, which was originally designed for non-verbal individuals, is a visual system for interpersonal communication that utilizes conventional symbols requiring minimal analytical ability. Traditionally, the PIC representational symbols are used in a printed form. A recent testing program of a PIC subset with either paper or CRT screen imaging, and with or without accompanying voice support (human or computer synthesized), indicates some interesting preliminary results. For the handicapped and non-handicapped persons tested, there seems to be little difference in the visual medium but, for the audio parameter, the monotone computer "voice" can be a detrimental factor.

INTRODUCTION

Interpersonal communication is an essential need for any individual in any environment, and perhaps the most effective and dynamic means of increasing the opportunity for social cohesion [3] is verbal communication. However, there are many persons in society who are incapable of accommodating complexities in verbal communication, and there are a number of groups of such individuals with verbal communicative problems who have benefited from some nonspeech communication mode [11]. On a general level, these groupings include mentally handicapped, cerebral palsied and aphasic persons.

During the last few decades, a number of nonverbal communication systems have been developed to augment verbal communication. The best known of these, designed and developed by C.K. Bliss [2] in 1965, is a nonalphabetic communication system which uses ideographic symbols to represent concepts through simple line drawings [13]. The Bliss symbol system was to be, originally, a written international language rather than an augmentative communication system for non-verbal individuals [9], but it has been used successfully in the latter mode at, for example, the Ontario Crippled Children's Centre since 1971 [8], primarily as a means for expressive communication [4]. Recently, Blissymbolic graphic images have also been incorporated into videotex under Canada's Department of Communications, Telidon applications development program, as part of a longer term goal to improve interactive individual communication through computer technology [10].

The success of the Bliss system as an alternate form of communication is evident from its international acceptance, but there are many nonverbal individuals who are unable to invoke the analytical abilities needed to cope with the high level of abstraction basic to the symbols [5]. Thus, there is also a need for a nonverbal communication system which has only minimal analytical requirements and which, therefore, relies much more



Figure 1. Analytical representation for television (Bliss).

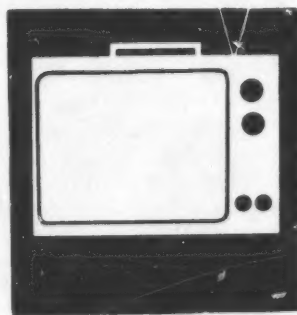


Figure 2. Pictorial representation for television (PIC).

heavily on representational components. The Pictogram Ideogram Communication (PIC) system developed by S.C. Maharaj in 1978 is just such a visual system of communication which utilizes conventional symbols that are readily recognized by most people [6]. The system was designed for nonverbal individuals, and has been used with mentally retarded, cerebral palsied and aphasic persons. The Pictograms have a concrete relationship with the items and objects being represented, while the Ideograms present ideas as symbols. (See Figures 1 and 2.)

At the University of Regina in Saskatchewan, a research and development group is involved in applications of relatively inexpensive microtechnology to improve communication capabilities for physically disabled persons and mentally handicapped individuals [1]. During the past year, this Mathesis Group has implemented a representative subset of PIC symbols for display on a monitor, with accompanying computer-synthesized voice support, in order to investigate two basic questions:

- (a) Does the change from a flat, printed symbol card to the presentation of PIC symbols on a video monitor have a significant effect on performance?
- (b) Does the change from instruction given by a human voice to instruction given by computer-generated voice lead to a significant difference in performance?

This investigation is part of a longer-term program to establish a computer-based, PIC training and communication centre, and answers were sought to (a) and (b) above through four tests that were designed to secure comparative results for four test groups (two consisting of mentally handicapped and two of non-handicapped persons). Results and preliminary conclusions from the testing are included in the discussion below.

THE TESTING

In order to have a viable electronic medium for representing PIC symbols, a microcomputer-driven monitor (rather than, say, a 35mm automated slide system) was selected for the pilot project. The hardware base chosen was an Apple II Plus; this is a popular home microcomputer which is widely used in educational and vocational environments, as well as in recent Telidon developments [12]. (A 48K configuration with two five-and-one-quarter inch floppy drives and a black and white monitor was selected.) An Apple tablet permitted easy creation of the screen symbols, and just the standard Apple keyboard was a satisfactory input device for this testing program.* A Votrax Type-N-Talk text to speech synthesizer was acquired and, since this requires only a serial interface, it could be incorporated into the hardware system without modification. The available software was adequate: the tablet includes its own software and the Votrax unit can be invoked

* Preliminary investigation is underway into the use of a touch-sensitive screen overlay. This type of man/machine interface promises to be very effective in a full learning and communication PIC environment, particularly for composing and displaying PIC-sequence messages.

directly from Applesoft BASIC.

(a) The Tests. Four basic tests were devised for approaching questions (a) and (b) above:

Test I: Designed to determine the ability of an individual to classify PIC symbols displayed on the CRT screen. Instruction was given by the tester.

Test II: To determine individual ability to identify PIC symbols, from a set of three symbols, when an instruction is given; 2" by 2" symbol cards were used. Instruction was given by the tester.

Test III: Similar to Test II, except that the symbols were computer displayed rather than printed card displayed.

Test IV: To assess individual ability to identify a symbol from a set of computer displayed PIC symbols. Instruction was given by the Votrax voice generator.

(b) The Subjects. Four groups of subjects were used for the testing program.

Group A: Seven subjects were used for this group, ranging in age from 4-3 years to 4-11 years, with an average age of 4-6 years.

Group B: Six mentally handicapped individuals were placed in this group, ranging in ages from 4-6 years to 10 years, with an average age of 7-1 years. The expressive vocabulary of these individuals, as reported by the parent(s), ranged from no intelligible speech and language to a vocabulary of about 100 approximated words of common nouns, some verbs and personal names.

Group C: Nine individuals ranging in age from 7-7 years to 9-1 years, with an average age of 8-1 years, formed this group.

Group D: Six mentally handicapped adults were placed in this group, with an average age of 27-2 years. The expressive vocabulary of these individuals, as reported by the parent(s), ranged from 5 intelligible words to a maximum of 100 approximated words of common nouns, verbs and personal names, with two individuals on occasion attempting word combinations.

(c) Symbol Representation. Twenty-seven PIC symbols of common nouns were randomly arranged in sets of 3 per test page, with a total of 9 test pages. Each test page was presented 3 times during the actual test so that all three symbols could be assessed. For Tests I, III and IV, the test pages were retrieved from disk and displayed on the video monitor, while for Test II, the same 27 symbols, printed on the 2" by 2" cards used for the traditional assessment and training in the PIC program [7], were mounted in the same sets of 3 on cardboard measuring 23cm by 10cm.

(d) General Procedure. The procedure for all four tests was adapted from the Assessment Procedure outlined in the PIC Manual [7]. Each subject was seated in front of the monitor and a three-symbol set was displayed on the screen (or with the test card) and the instruction was given.

- [i] If the subject responded correctly (by pointing or labelling), the item on the data sheet was marked correct and the next symbol set could be displayed.
- [ii] If the individual did not respond in five seconds, the instruction was repeated (by the tester or by Votrax, as appropriate). If the response was correct, the item on the data sheet was checked, and the next symbol set displayed.
- [iii] If the response in [ii] was incorrect, the item on the data sheet was marked with an (X) and the next symbol set was displayed.
- [iv] If there was no response in [ii], even after the instruction was repeated a second time, the item was marked incorrect and the next symbol set displayed.

It should be noted that on Test IV, the first two items were used to familiarize the subject with computer generated speech. The results were calculated using the remaining 25 test items.

RESULTS AND DISCUSSION

Since 4 tests were administered and 4 groups were involved in this project, the results will be detailed first by intra-group performance on the tests, and then on a combined basis for an answer to the two questions posed.

Group C was given Tests I and IV. Test I called for the labelling of symbols as they were presented on the video monitor in sets of 3 and without any text. The group response was 95,47% correct, and this agreement was taken as a positive indicator that further testing using computer-displayed symbols should pose no serious problems. On Test IV, the result was fractionally higher (95,55%); furthermore, of the 10 errors, 4 were recorded for 'Hat' and 3 for 'Water'. Interestingly, these two items were on the same test page and when one symbol (the incorrect one) was indicated for one response, the subjects seemed to respond from a visual standpoint and eliminate as a possibility the symbol(s) already "identified" in that set, rather than continuing to respond to the instructions.

Group A received Tests II, III and IV. Only one error was recorded on each of II and III, for a total correct percentage of 99,47; the subjects seemed to respond equally well to both means of visual presentation. On Test IV (using computer generated voice), this group achieved an 84% correct response. The subjects were given 2 trial items to familiarize them with the procedure and the computer generated voice, and the adaptation usually became evident only after the second test item. The substantially lower group performance on Test IV, as opposed to that on Test III, seems to be in response to at least two factors which emerged:

- [i] With the available software, the delay (approximately 8 seconds) from the appearance of the symbols on the screen to the presentation of the instruction through computer generated voice appeared to result in a lack of attention to task and occasional missing of the given instruction.
- [ii] The total length of time the subjects had to sit (approximately 30 minutes total test time) to complete

the tests in sequence seemed to exhaust some of the subjects who are not normally accustomed to concentrate and attend to a task for sustained periods.

Group B, composed of 6 mentally handicapped individuals with an average age of 7-1 years, received Tests II, III and IV. For Tests II and III, which assess performance for the two mediums of symbol presentation, the accuracy for identification was virtually the same --- 98,15% and 97,53% respectively. On Test IV, this group scored only 74% correct on the identification of symbols when the instruction was presented through computer generated voice. Although it is difficult to differentiate which variable had greater influence on performance, adverse reaction to computer generated speech or the observed limited attention to task, a comparison with the Test III results (97,53%) would indicate that computer speech adversely affected performance, for this group of subjects.

Group D consisted of six mentally handicapped adults; on Tests II and III, once again, there was no significant difference observed by the change from the printed symbol cards to the presentation of PIC symbols on the screen (the group scores were 98,15% and 98,76%, respectively). On Test IV, the group performance was 79,33% correct, with only 5 of the 27 test items gaining 100% agreement. Of note is the fact that the same individual who recorded all the group's errors on Test II and Test III accounted for over 50% of their errors in Test IV (16 out of 31 errors). But again, comparison of the group results for Test III and Test IV indicates that the synthesized speech adversely affected performance.

Test results when group performances are combined is summarized in Table 1. The combined scores of Groups A, B, and D (19 subjects) are presented by test item, for Tests II, III and IV, as percentages. A comparison between the combined-group results for Test II and Test III indicates that there was no demonstrated advantage or disadvantage in changing the visual medium for PIC symbols from printed cards to video monitor: the mode is 100% both for Test II and for Test III. However, for this combined group, a comparison of performance between Test III and Test IV is significant: the mode on Test IV is only 78,9%, as opposed to the 100% for Test III. This difference, if influence of other variables is not accounted for, would indicate that computer generated speech indeed affected performance for the groups, but adversely.

Test Item Description	Test II Group Score (percent)	Test III Group Score (percent)	Test IV Group Score (percent)
Cup	94,74	100	31,57
Book	94,74	94,74	52,63
Hot Dog	100	100	89,47
Woman	100	100	100
Toothbrush	89,47	100	94,74
Television	94,74	94,74	94,74
Hamburger	100	100	94,74
Scissors	100	100	78,94
Bread	100	100	100
Spoon	100	94,74	78,94
Cat	100	100	78,94
Pants	100	100	78,94
Apple	100	94,74	89,47
Sock	100	94,74	84,2
Man	100	100	68,4
Shoe	100	100	68,4
Hat	100	100	47,37
Shirt	100	94,74	84,2
Table	100	100	94,74
Fork	89,47	100	100
Car	100	100	68,4
Chair	100	100	73,68
House	100	100	84,2
Ball	100	100	89,47
Pencil	100	100	78,94
Water	100	94,74	73,68
Knife	100	100	78,94

Table 1: Groups A, B and D combined (19 subjects).

CONCLUSIONS

The major purpose of the testing program presented here was to obtain preliminary indications about visual representation of Pictogram Ideogram Communication symbols (in printed form versus CRT screen form) and about effectiveness of accompanying voice support (human versus computer-synthesized). Assessment of these two parameters is important for the longer term program of establishing a PIC training and communication centre using relatively inexpensive, off-the-shelf microcomputer technology. Based on results from the testing program with the four groups of individuals, two tentative conclusions may be made:

- (a) There is no significant difference in group recognition of the symbols when the medium is changed from a printed format to presentation on a video monitor.
- (b) Group performance related to instructions given by the tester (human voice) as opposed to Votrax-generated voice indicates less favorability towards the latter means of instruction.

However, this apparent negative impact when human speech is replaced by synthesized speech cannot be accounted for in simplistic terms only, in this program, since other factors could significantly influence subjects' performance:

- [i] It was evident that the time-lag between the screen display of the symbol and the generation of the instruction on Test IV (almost 8 secs), over 25 trials, could have contributed to problems in attention to task. On Test III there was no such delay.
- [ii] Age and mental ability of the subject appear to have a direct relation to test performance, of course. The two groups of mentally handicapped individuals (Groups B and D) and Group A (average age 4-6 years) displayed attention to task problems, and the monotonous computer-generated voice did little to sustain interest and attention.
- [iii] Novelty of the synthesized voice affected some subjects in a minor way while others had noticeable difficulty adjusting to the toneless quality.

Modifications of existing software could reduce some of the observed delay between screen symbols, but relatively inexpensive hardware has limited performance. The "quality" of words could be improved by sending phonemes to the Votrax unit, rather than having it do the parsing of words that are input through the keyboard. Improvements in PIC symbol resolution (the black and white screen used displays a 192X280 dot matrix) could permit finer detail and symbol groupings with more components. These are some of the several interesting areas of extension under consideration for incorporating microtechnology into Pictogram Ideogram Communication.

ACKNOWLEDGEMENT

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A MODEL FOR ADMINISTERING COMPUTER-BASED EDUCATION

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ABSTRACT

During the five-year period from 1975 to 1980 the Delaware PLATO[®] Project grew from its initial one-terminal demonstration phase into an Office of Computer-Based Instruction with one hundred faculty members developing computer-based learning materials in thirty subject areas and testing them with students using the two hundred terminals connected to the Delaware PLATO system. Enabling this activity is a model for administering computer-based education which consists of ten key factors: faculty leadership, system selection criteria, centralized control of resources, independence in project management, development of new materials, clear statement of mission, financial rationale, staff development, publication of research, and efficiency in on-line project management. These factors are discussed with illustrations of the organization of the Office and of the Delaware model for courseware development.

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INTRODUCTION

When the University of Delaware began its demonstration of computer-based education, few persons expected it to grow into the Office of Computer-Based Instruction. When PLATO was chosen as its main developmental tool in 1975, the growth shown in Figure 1 began. The Fifth Summative Report of the Delaware PLATO © Project [1] documents the history, development, and results of thirty departmental implementations of computer-based education, describing how faculty members are publishing PLATO lessons, demonstrating them at conferences, and using them to generate publishable research in their respective fields.

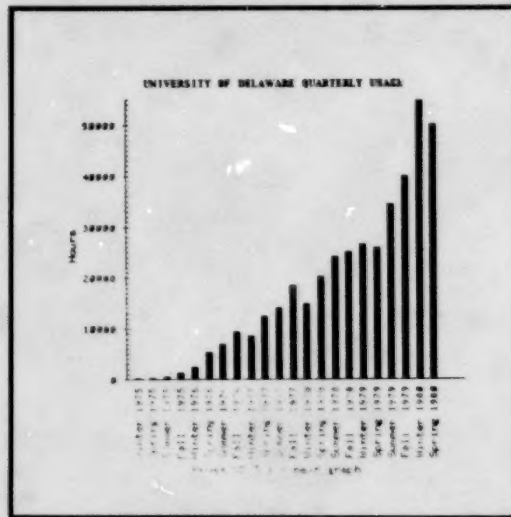


Figure 1. Quarterly Growth of the Delaware PLATO Project

Many persons have asked for an explanation of the organizational factors which have enabled this activity. It is the purpose of this paper to present, discuss, and illustrate ten factors which collectively constitute the Delaware model for administering computer-based education.

FACULTY LEADERSHIP

It is appropriate to begin this presentation of the organizational factors which have contributed to the success of computer-based education at Delaware by discussing its driving force, namely, the faculty. From the beginning of the project care was taken to involve faculty members in leadership roles. It was recognized that unless faculty members were willing to invest time in learning how to use computer-based education, designing new learning materials, and implementing them with students, any computer-based educational project would lack the basic academic support needed to sustain it. Similar projects have floundered at other universities because projects were initiated by and run by the administration instead of by the faculty. If the faculty members at Delaware had not shown sufficient interest in exploring computer-based education, the project would have been discontinued.

Faculty members initiate projects by writing proposals. Table 1 shows a list of items which faculty members discuss in these proposals.

Table 1

Items Which Faculty Members Discuss in Project Proposals

1. Manner in which proposed project relates to the curriculum.
2. Instructional strategy to be used.
3. CBE system to be used.
4. Reasons why this is a good use of proposed CBE system.
5. Research potential (if any).
6. Significance of proposed project in investigator's field.
7. Number of students to be served.
8. Number of terminal hours required per term with proposed class schedule.
9. Hours of lesson material already available which can be used in this project.
10. Hours of lesson material to be programmed.
11. Peripherals needed (if any).
12. Duration of project for lesson development and for student use.
13. Evaluation criteria -- how will it be determined whether the project is a success or a failure?
14. Exportability -- where and how can these materials be used off campus?

For each department one of the faculty members has been designated project leader. This faculty project leader has the final say over the content of computer-based educational materials and of their place in the overall curriculum of the department. By serving as proposal writers, content experts, curriculum developers, student evaluators, and packagers of materials for off-campus delivery, faculty members have assumed a major, time-consuming role. It should be pointed out that no extraordinary incentives have been offered to the faculty. Their dedication to computer-based education stems from an innate desire to improve instruction.

SYSTEM SELECTION CRITERIA

Selecting the right system was a key element in developing the faculty interest, support, and leadership discussed above. All available computer-based education systems were carefully examined by a faculty committee, and their advantages and disadvantages were compared. Careful consideration was given to the kind of instructional strategies which the systems could support, the quality of their student learning stations, the features available to instructors and authors, the dissemination of lesson materials, and their viability for the future. Table 2 shows a list of the system selection criteria which were considered under each of these categories.

Table 2

System Selection Criteria

1. Support for Instructional Strategies
 - tutorial
 - drill-and-practice
 - simulation
 - gaming
 - problem solving
 - testing
 - computer-managed instruction
2. Requirements of the Student Learning Station
 - high-resolution graphics
 - programmable character sets
 - animation
 - touch input or light pen
 - student control keys
 - instantaneous response time
 - support of peripheral devices
3. Features for Instructors and Authors
 - program libraries
 - indexes and routers
 - student record keeping
 - communication options
 - programming aids
4. General Operational Characteristics
 - reliability
 - maintainability
 - accessability
 - ease-of-use
 - security
 - documentation
5. Dissemination Networks
 - international program distribution
 - communication links
 - user groups
6. Future Viability
 - corporate commitment to CBE
 - flexibility of system design
 - planned use of microelectronics

After nearly a year of careful study the faculty committee recommended PLATO, informing the administration that there was no other system which came close to meeting the system selection criteria as well as PLATO. The importance of PLATO to the success of computer-based education at Delaware cannot be over-emphasized. No other system could have sustained the level of faculty interest and excitement that PLATO has. Sherwood [2] has pointed out the important aesthetic aspects of interactive computer systems, without which a broad base of faculty support for PLATO could not have been developed.

CENTRALIZED CONTROL OF RESOURCES

Sorlie and Essex [3] pointed out the importance of maintaining a central control of authoring if computer-based educational projects are to be meaningful and integral parts of a school's curriculum. At the University of Delaware centralized control has been maintained over funding, lesson development, hardware development, and system operation. A careful distinction has been made between developmental and nondevelopmental use of the computer, with game playing and other forms of recreational use restricted by site and by times so that the mainstream of use emphasizes serious development of curricular materials. If centralized control is not maintained over system and programming resources, a dangerous fragmentation and alienation within a project can occur. Centralization has allowed a careful process of quality control to be built into lesson development at Delaware.

INDEPENDENCE IN PROJECT MANAGEMENT

It may seem contradictory to speak of independence having just advocated centralized control, but the way in which this control is maintained has allowed an independence in project management. An explanation of the organizational chart of the Office, given in Figure 2, will show how this works. The Director of the Office reports to the Provost and receives recommendations from a faculty advisory committee regarding proposed new projects. All proposals for on-campus projects are received by the Director who upon consultation with the faculty committee, and the senior staff of the Office forwards them with an appropriate recommendation for funding to the Provost. Also reporting to the Provost are the heads of the colleges and divisions at the University. By being organized alongside of these divisions instead of underneath one, the Office is free to initiate and to evaluate projects in all divisions according to its mission.

The Office consists of four main components, namely, operations, outside user services, research, and program development. It is through program development that the main interface is made with other departments on campus. Organized according to the departments which request services from the Office, for each project there is a faculty project leader who as the principal spokesperson for the department has the final say as to the content of the programs. The project leader works with other faculty members in the department in considering new ways in which computers might assist instructional efforts. The project leader also works closely with Office programmers and coordinators who implement the program and who in turn report to project managers in the Office. Timelines, target dates, and milestones for completion have been established for each project. The loop which has been illustrated in Figure 2 among the coordinators, programmers, and faculty project leaders is a vital interaction between the centralized office and the colleges and divisions.

DEVELOPMENT OF NEW MATERIALS

The faculty-staff loop in turn becomes the nucleus of the Delaware model for courseware development. Nievergelt [4] has pointed out that "Today it makes no sense to start a CAI project unless one is willing to write most of the necessary courseware." Whereas this is not necessarily true for every subject matter, it was recognized by the faculty committee in 1974 that although good examples of the use of PLATO could be found in existing program libraries, there were many new applications which needed to be explored, and therefore a heavy emphasis upon program development was planned. Figure 3 shows the present state in the evolution of the Delaware model for courseware development. Using a systems approach it contains a proposal stage, a design stage, a programming stage, and a dissemination stage. It departs from the traditional systems

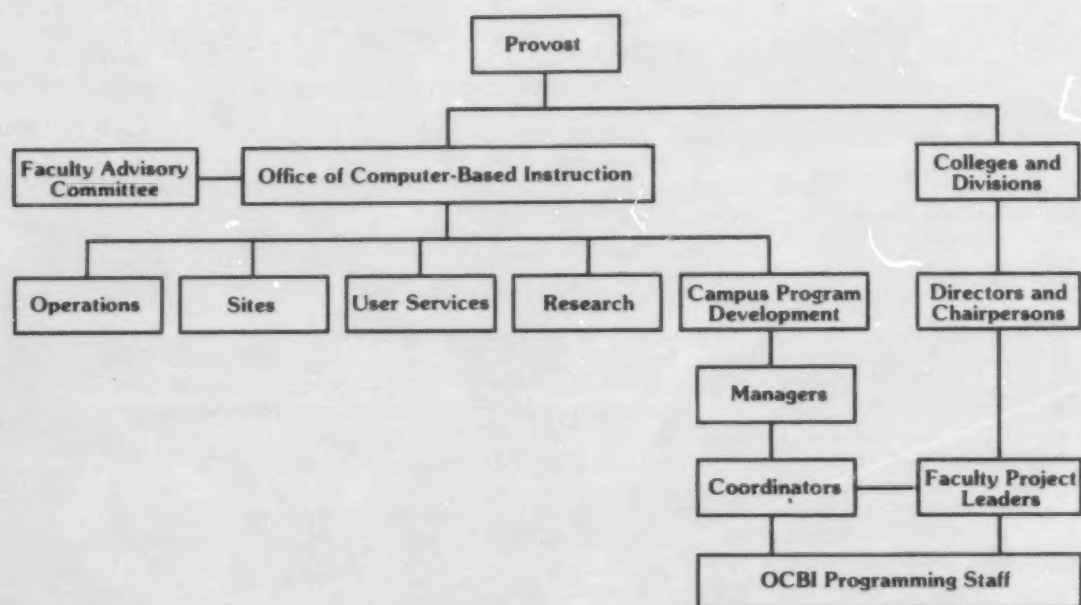


Figure 2. The Delaware Model for Project Management

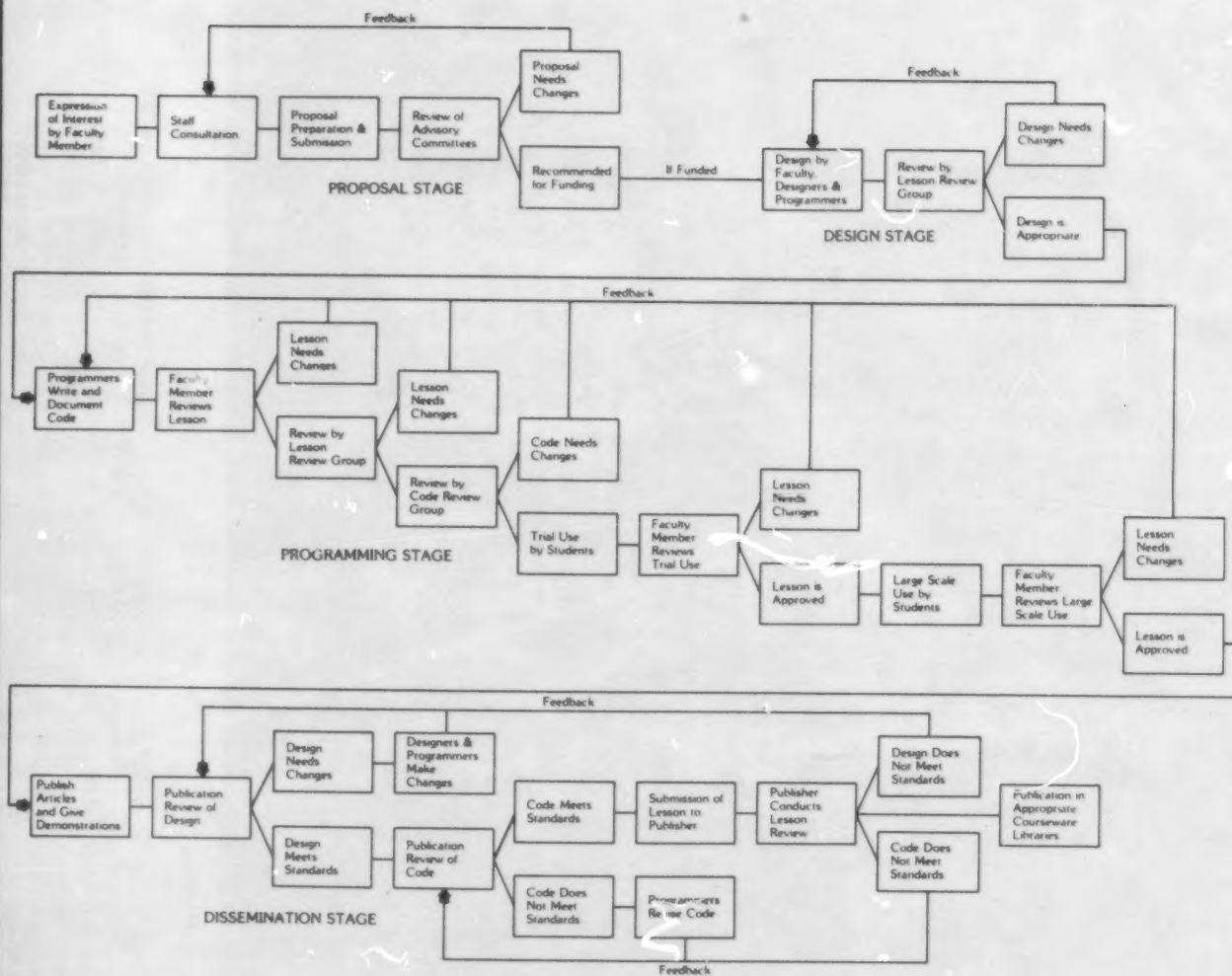


Figure 3. The Delaware Model for Courseware Development

approach in that it does not contain a separate evaluation stage; rather, evaluation is incorporated throughout the model in a variety of feedback loops.

At the proposal stage an advisory committee works with the faculty and the staff in refining the proposal until it best addresses all of the issues which were contained above in Table 1. Once the proposal is funded it proceeds to a design stage which has two important characteristics. First, lessons are designed by a team consisting of faculty members, designers, and programmers, and second, a lesson review committee looks over the design and helps the design team refine it by feeding back information regarding suggested changes until the design is appropriate to the material and proceeds to the programming stage. Seiler [5] has more fully described this team approach to lesson design.

In the programming stage the faculty member regularly reviews the lesson as it is written by programmers and tested with students. When a successful large scale use with students has been attained the faculty member publishes evaluations and gives demonstrations of his material as the first part of the dissemination stage. At the same time the lesson begins the process of publication review which culminates in publication of the lesson on the international PLATO network.

CLEAR STATEMENT OF MISSION

Francis [6] has pointed out how important it is for any developmental project in computer-based education to have a clear understanding of its mission. Without a clear understanding as to how it will be evaluated, a project can fall into an abrupt and dismal ending when its staff and its administration differ on what constitutes a successful outcome. The original mission of the Delaware PLATO Project was stated quite simply by the administration, namely, to show widespread and sustained interest in using PLATO on the part of faculty. The wisdom of this statement can be realized by considering the large investment of time and energy required by faculty members who want to become developers and innovators in the field of computer-based education. The administration knew that the quality of its faculty was high, and it also knew that if Delaware faculty members were willing to invest the time needed to implement PLATO in their courses, then PLATO was indeed worth having at the University.

Since those early days a much more sharply defined statement of mission has been developed as is encompassed in the goals of the Office which are categorized under educational leadership, program development, campus outreach, service, research, and student benefits. Whereas it is beyond the scope of this paper to explain these goals, they are discussed in the Synopsis of the University of Delaware's Office of Computer-Based Instruction [7].

FINANCIAL RATIONALE

Francis [8] also pointed out the importance of understanding the sources of funding for a project. Sources of funding for the Office of Computer-Based Instruction have included the University's instructional budget, grants from foundations endowed within the University, grants from outside funding agencies, and income from courseware developed, seminars given, and computer services offered through contracts with outside customers. There are three important aspects to the financial rationale whereby these funds are dispersed. First, there is a strong institutional commitment to computer-based learning at the University, and in line with this commitment the University allocates from its instructional budget the funds necessary to provide computing services to on-campus users. Second, the funds are all centrally controlled and dispersed by

the Office, with no charges made to participating departments for either personnel or computer services. Third, whereas during the first few years of the project any income earned from outside contracts and grants reverted back to the University's general fund and was not available to the project, more recently a policy has been followed whereby the Office receives the income from contracts and grants and can use this income to meet the needs of its growing user community.

According to this financial rationale the University bore the initial cost of installing its PLATO system. Income from contracts and grants has subsequently aided in upgrading the system to meet the needs of its growing user community. It is fortunate that the cost of PLATO has continually declined. Whereas its critics said that PLATO was based on an old technology and would never make it into the 1980's, to the contrary it has incorporated into its design advances in microelectronics which have allowed it to emerge in the 1980's in a MicroPLATO format.

STAFF DEVELOPMENT

The most important resource for any developmental project is its staff. Staff of the Office of Computer-Based Instruction can be thought of in two broad categories, first, programming and operations, and second, design and evaluation. The first professional hired in the Delaware PLATO Project was a top-flight programmer who had the ability to teach others how to program in order to develop an authoring community, and who also had in-depth knowledge of the PLATO system and could insure that the technical operation of the program ran smoothly. When funds became available to hire a second professional, an educational psychologist was hired who had successfully designed many PLATO lessons and who could structure the project's design and lesson review procedures in order to insure that programs written at the University of Delaware would be of the highest quality. As the staff has grown from those first two professionals to its current level of thirty-four full-time and fifty-three part-time members, care has been taken to balance the programming and technical side with the design and evaluation side, and the original two professionals are now associate directors responsible for these two respective areas.

When the project started there was a shortage of professionals qualified to work in computer-based education, and this is still the case today. For this reason it was vitally important to initiate a training program for programmers and designers. From the first programming and design seminars offered in 1975 a complete training program has evolved which serves not only the training needs of the University but which has also been used through the Office's outside user services component to meet training needs on an international basis. Table 3 shows a list of the training courses available in this program which is offered four times a year for the University and additionally as many times as outside customers request it.

PUBLICATION OF RESEARCH

A very important requirement in the promotion and tenure process at the University of Delaware is research and publication. Faculty members are using the PLATO system to aid them in this endeavor in three ways. First, they are publishing their PLATO lessons on the Control Data PLATO network, an activity which has been considered to be equivalent to the publishing of textbooks. Second, faculty members have been using the data saving features of the PLATO system to collect information on learning behaviors as students work through their lessons, and the analysis of these data have led to important discoveries regarding student learning styles and the optimal ordering of instructional

Table 3

Courses in the Delaware CBE Training Program

Introduction to the PLATO system
Orientation for Instructors
Beginning TUTOR Programming
Advanced TUTOR Programming
PLATO Lesson Design
PLATO Lesson Review and Critique
TUTOR Programming Review and Critique
Site Management Training
Computer-Managed Instruction

materials. Qualitative evaluations of students' opinions are also required for every course which uses PLATO at the University. The results of these studies of student learning behaviors and attitudes are being published in educational research journals in the respective fields of the faculty members. Third, faculty members are publishing the results of pure research using the PLATO system as a stimulus-presenting, response-recording device in a variety of perceptual and attitudinal studies.

It is interesting to note that when the PLATO system was first installed at the University of Delaware, research was not thought of as one of its goals. Now it is a primary aim.

EFFICIENCY IN ON-LINE PROJECT MANAGEMENT

The Office of Computer-Based Instruction has a reputation for being one of the most efficient offices on the campus. This is largely due to the on-line management activities which have been supported through the communication features of the PLATO system. All of the communication within the Office and most of the communication between Office staff members and faculty members is handled electronically through PLATO's Personal Note system. Project reports, information on the operation of the PLATO system, catalogues of Delaware lesson materials, task assignments, classroom schedules, timelines, goals, and objectives are all maintained in utility programs written at Delaware for the smooth operation of the project. Using the PLATO General Notes facility whereby files of information can be read and responded to by groups of persons allowed access, special purpose files have been set up for various levels of staff discussion, University discussion, and the management of individual projects. Extremely helpful in reading these general notes files is a PLATO utility called the "cycloc" which automatically sequences note readers through the files they want to read showing them only those items which have been written or responded to since they last read notes.

SUMMARY AND CONCLUSION

Whereas the ten factors discussed above were by necessity presented sequentially, it is important to stress in concluding this article the dynamic interactions among them as they form the Delaware model for administering computer-based education. The role of the faculty goes beyond its primary one of proposing, designing, and implementing lesson materials. The faculty has also played a critical role in selecting a system, forming the faculty-staff loop, approving courseware under development, participating in the staff development program, publishing research, giving demonstrations, and participat-

ing in on-line project management. Neither should the effects of the system upon other factors be underestimated. It would have been extremely difficult to achieve the level of success which computer-based education has had on the Delaware campus with any system less capable than PLATO. PLATO has the esthetic appeal needed to arouse faculty interest, and it has the system features needed to support program development in a multidisciplinary setting. The PLATO system also provides a vehicle for publication and for efficient communication in project management.

The model for administering computer-based education did not exist in 1974 as it has been presented in this paper. As the Delaware PLATO Project grew, careful attention was paid to the identification of and the interactions among the factors contained in this model. Extremely helpful was Steinberg's analysis of critical incidents in the evolution of other computer-based educational projects [9]. The Delaware model is a combination of complex factors which interact with each other in a delicate system of checks and balances. Any proposed change to this model would be very carefully considered, given the effect which that change may have in the dynamics of administering computer-based education.

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POSSIBLE EDUCATIONAL APPLICATIONS OF THE MICROCOMPUTER

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ABSTRACT

Developments in the field of the microcomputer have created new possibilities for the effective implementation of computer-assisted and computer-managed instruction in educational institutes. There are, however, problems that will have to be overcome, inter alia, in connection with the design of quality courseware and the didactical evaluation of the available courseware (from overseas), the standardization of software and hardware and the compatibility of courseware to different microcomputers, the promotion of computer literacy and, related to this, teacher training and a general promotion of a "didactical" interest in the microcomputer and its application possibilities. Once these problems have been overcome, the microcomputer will make a meaningful contribution to better quality education in the RSA.

POSSIBLE EDUCATIONAL APPLICATIONS OF THE MICROCOMPUTER

1. INTRODUCTION

Merely a few years ago the term "microcomputer" would not have aroused much interest in the educationist or teacher. They certainly would not have related this term to an educational medium with the potential to give rise to statements such as the following:

"By the year 2000 computer-assisted instruction (CAI) will be the most important way in which people will learn at all levels and in almost all subjects." (7).

"The use of microcomputers for instructional purposes in the schools is growing rapidly and will have an incalculable effect on education." (8)

"By the year 1984 there will be millions of general-purpose microcomputers in schools, colleges and universities, with an even greater number available for educational use in the home (Thomas Dwyer: (13).

Virtually every article dealing with the possible uses of the microcomputer in education starts off by referring to the revolution that the microcomputer will bring about in education. However, it is significant to note that the initial unbridled enthusiasm over the possibilities of the microcomputer has slackened off in due course to a more realistic approach.

It can therefore rightly be asked what the current view is with regard to the possible educational applications of the computer, more particularly the microcomputer. The following paragraphs will therefore be concerned with the basics about microcomputers and how they can be implemented for the benefit of education on the one hand, while at the same time also clearly indicating that there are still serious problems to be overcome before the microcomputer can be optimally utilized.

2. MICROCOMPUTERS

As indicated by the name, the microcomputer is a small type of computer and portable, unlike the mainframe computer that often takes up a whole room. Despite its small size the microcomputer can fulfil all the potential functions of the mainframe computer, in most cases only less powerfully. In relation to the large computer the price is particularly reasonable and in fact within the reach of schools and households (hence the alternative name of personal computer). The difference between a micro and minicomputer is still expressed mainly in terms of price and capacity.

In its simplest form the microcomputer usually consists of four basic parts (see Fig. 1).

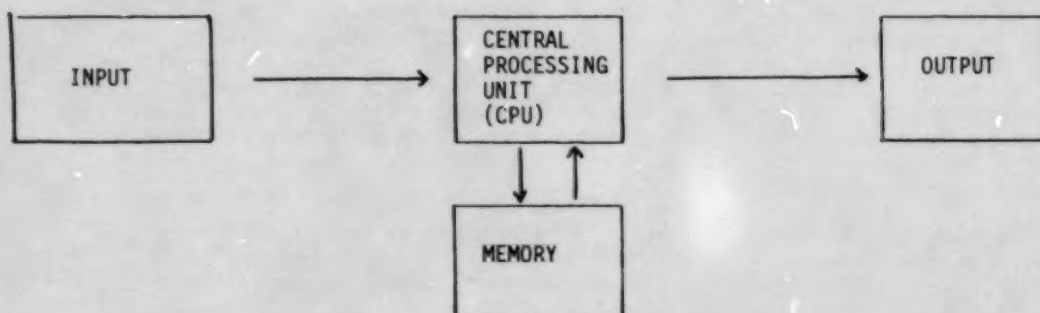


Fig. 1: The basic elements of a microcomputer

The central processing unit is the 'brain' of the system and performs all the calculations and controls everything related to the system. Although all data are coded in binary format, the user will be able to make use of mainly ordinary numbers and words in his interaction with the computer.

The memory is needed to preserve the data as well as the instructions relating to the processing of the data. In this regard there is an important difference between the volatile, temporary memory (random access memory (RAM)) and the permanent memory (read-only memory (ROM)). The ROM contains the data and instructions that remain unchanged and which should be at the disposal of the central processing unit as soon as the computer is switched on. The ROM is built into the computer by the manufacturer and can usually not be changed by the user. The RAM, however, can be changed rapidly and easily and at random and is usually implemented by the user to preserve his own programmes. The RAM is also implemented as a temporary repository for the variables used in the current programme. The RAM has the disadvantage that if the power is switched off all the data contained in it are lost.

The capacity of a microcomputer is usually measured in terms of the amount of data that can be handled by the memory (the data unit is a byte consisting of eight binary digits). The capacity of memories varies from 4K (K = one thousand bytes) in the TRS - 80 colour microcomputer to 128 K in the new Apple III microcomputer. A memory of 4 K to 16 K is usually adequate for use in the home (and for games). The capacity of the computer's memory (RAM and ROM) will determine the scope and the complexity of the programmes that can be developed (and in which the data are included). At least 8 K bytes RAM must be provided for the user's programme and data, while a further 8 K is needed to preserve a highlevel language (such as BASIC). Additional memory will be needed when floppy discs are used to preserve the programmes, so for school use a minimum of 32 K or 48 K should probably be considered.

Input and output mechanisms

These concern keyboard terminals, printers, synthesizers of sound and speech, speech processors, video screens, floppy discs and tape recorders.

In defining a microcomputer it is essential to refer briefly to the different computer languages used. A distinction should be made between the assembly language, programming language and authoring language. Only the latter two languages are important to a person not interested in entering in depth into the technical aspects of computer language.

A few of the best known programming languages are BASIC, FORTRAN, COBOL, PLI and APL. In recent times authoring languages such as CAN (completely arbitrary name), LOGO and TUTOR have been developed to facilitate the construction of programmes for courseware. These languages also enable the teacher or didactitian to develop courses for the computer without any knowledge of programming languages or experience of programming. A further advantage of these languages is that the work can be done in roughly a quarter of the time usually required by an experienced programmer.

When the problems concerning the use of the microcomputer in education are discussed later (in Paragraph 5), the different parts of the microcomputer and the restrictions imposed on the use of the microcomputer in this regard will also be dealt with.

3. THE NEED FOR MICROCOMPUTERS IN EDUCATION

There is a quantitative as well as a qualitative side to the problems currently experienced in education. In the developed countries of the world (*inter alia* also in the developed sector of the RSA) there is a growing need for an improvement in the quality of education. This improvement in quality is related to matters such as individualization and tempo differentiation and the development of more satisfactory classroom practices (cf. the reference to simulation programmes later). Also related to this are efforts to rid the teacher of all inhibiting administrative obligations to enable him to devote more time to teaching.

With regard to the developing countries the problem lies in the large numbers of learners, limited funds, poorly qualified teachers and a high pupil/teacher ratio (7). Before the quality of education can be markedly improved, answers will first have to be found to these problems. As a matter of fact, enthusiasm for the (micro)computer resulted from the fact that many of these problems could be combatted through the use of the computer/microcomputer.

For more than two decades investigations have been conducted into the possibilities of the computer for use in education, but it has only been with the appearance of the microcomputer during the past few years that the school has been directly involved. The considerably smaller, cheaper and portable microcomputer has shown that it can be fruitfully incorporated in education in various ways. Gleason (11) reports a dramatic increase in the rate at which teachers have recently been accepting the microcomputer in education.

To obtain an idea of the significance of the microcomputer for education it is necessary to discuss the most important application possibilities.

4. POSSIBLE EDUCATIONAL APPLICATIONS OF THE MICROCOMPUTER

The various possible ways in which the microcomputer can be utilized in the educational situation are subsequently explained in brief since most of these applications are already well known.

4.1 COMPUTER-ASSISTED INSTRUCTION (CAI)

Contained in this term are probably some of the most exciting possibilities of the computer for use in education. At the same time however, it is also the one application that poses particular problems with regard to its implementation. On the positive side there is the interactive use of the computer and the consequently active involvement of the learner. The possibilities of individualization arising from the fact that the pupil can work at his own pace is a

Problem-solving and free dialogue mod

Through the computer programme new or unfamiliar situations are created for the learner and although he has the necessary knowledge and skills for it, he has to find a correct procedure or use heuristics to solve the problem (12). This modus is related to what Rushby calls the "conjectural paradigm" in which the computer supports the learner in his manipulation and testing of ideas and hypotheses to acquire new knowledge in this way (17). The supposition is that new insights can be obtained when the student explores and manipulates data and the computer is used as an aid (e.g. to make computations) (16). The learner enjoys a great measure of individual liberty. Naturally such programmes are difficult to develop and few of them have yet been used in schools. The last two modi of CAI are mostly still being used and developed at tertiary education level.

4.2 COMPUTER-MANAGED INSTRUCTION

The learner does not necessarily come into contact with the computer in the case of computer-managed instruction. The computer is used however, to guide the teaching and learning procedures in the class and at the same time to lighten the teacher's administrative burden, so that he can pay more attention to the individual needs of the learners. Attention will therefore be paid to the use of the computer for the administration and control of classroom activities and to report on the learner's activities and to schedule them.

"CMI (writer Splittgerber) is defined as an instructional management system utilizing the computer to direct the entire instructional process, including perhaps CAI as well as traditional forms of instruction which do not require the computer, such as lectures and group activities. CMI has some or all of the following characteristics: organizing curricula or student data, monitoring student progress, diagnosing and pre-scripting, evaluating learning outcomes, and providing planning information for teachers" (20).

The significant difference between computer-assisted instruction and computer-managed instruction is therefore that in the case of the former the computer has an instructional function, while in the second it performs a management function.

By way of summary it can therefore be stated that although the computer works in the background in computer-managed instruction, the aim is to promote the effective progress of teaching and learning through the execution of certain functions and at the same time to lighten the administrative task of the teacher. These functions are all of a management-supportive nature and comprise the following:

- . The construction, marking and analysis of tests for diagnostic and evaluation purposes;
- . Keeping a record of the student's achievement and progress through the course;
- . On the basis of the knowledge of the student and the structure of the course, individual guidance is given to each student and he is advised in respect of the route he has to follow through the structured course.

particular didactical gain. It is almost unique in the sense that no other education medium creates this possibility at the same level. Research has already shown that the learner performs just as well if not better than with conventional education, while the learning time is decreased and the attitude of pupils in respect of the computer is positively influenced.

A practicable distinction is made between the so-called adjunct CAI and primary CAI (3). The former concerns short educational programmes on a variety of topics (remedial, enriching, etc.) to supplement the usual instruction, while the latter (also called substitute programmes) are educational programmes of an independent nature, thus covering an entire course. In the planning of a total strategy for the implementation of the microcomputer in education, this distinction would be a useful way of distinguishing between research efforts and of laying down guidelines as to where the emphasis should fall in development work.

After years of research into computer-assisted instruction in England the following conclusion was arrived at: "The major benefits from computer assisted learning are likely to be qualitative in nature - teaching new topics that could not be taught with existing methods, assisting in the teaching of 'higher order' skills such as decision-making and problemsolving and improving the quality of existing teaching by tailoring it more sensitively to the individual needs of the active learner (5).

Some of the best known ways in which the microcomputer is used within the context of computer-assisted instruction are the following:

Drill exercises

This is the simplest way in which the microcomputer can be utilized for interactive educational purposes and the name actually speaks for itself. It is expected of the learner to do the exercises presented by the computer (for example arithmetical computations) and he receives an immediate response from the computer to his achievement (12).

Tutorial

In this method of computer-assisted instruction the subject matter is taught to the learner through the computer. In addition the computer keeps accurate track of the learner's progress, thereby acting as a patient intermediary to make the subject matter accessible to the learner in accordance with his abilities (13).

Simulation programmes (simulation and gaming)

With the aid of simulation programmes the learner is progressively introduced by the computer through heuristic learning to specific subject matter and the theory on which it is based. While the computer was used in the previous modus of CAI to teach the subject matter and to monitor the learner's answers and check his progress, it is used here as an intermediary between the learner and a hidden model of some actual life situation (17).

In respect of simulation programmes on the computer, Rushby states the following which can be supported fully: "The use of simulations (and, as we shall see later, model building) is a powerful CAI technique which exploits some of the unique features of the computer as an aid to learning. It enables the student to experiment with situations which would otherwise be too expensive, too time-consuming or impossibly dangerous" (17).

- . Report is also made on the achievement and progress of the learners and also of the course in so far as it may be of interest to the learners, the teachers and the management of the educational institution (17).

Computer-assisted instruction (CAI) and computer-managed instruction (CMI) can be regarded as the two major categories according to which the computer can be used for instructional and learning purposes.

There are various ways in which the microcomputer can be used in education that are not directly intended to promote the teaching of specific subject matter, but that are of special importance in the process of teaching. Attention will briefly be paid to these.

4.3 THE PROMOTION OF COMPUTER LITERACY

It has been said that the next crisis in education will develop around the general ignorance that exists in respect of the place and possible uses of the computer in society. While an explosion of knowledge is taking place in the field of micro-technology which is of such a vast scope that it will change the total aspect of man's daily life during the next decade, relatively little is done in the schools to face this new problem. Computer technology has been adopted in virtually every aspect of business, cultural, social and even religious organizations as a means to improve the effectiveness and efficiency of operations (11).

Two aspects of computer literacy are mentioned, i.e.

- . how a computer works and
- . application and effect of the computer.

There is however still uncertainty about what would be the best strategy to promote computer literacy among the general public. One matter about which there is a fair degree of unanimity, is that a start should be made during teacher training. Dickerson and Pritchard (8) for instance, point to the increasing gap between technical experts and teachers (p.8) and they also state that there is a clear need for computer literacy courses in teacher-training programmes (p.12). From this point the matter should be carried through to the school where computer literacy courses should be provided to all students (12).

In a subsequent paragraph the problems surrounding computer literacy will receive further attention.

4.4 OTHER POSSIBLE APPLICATIONS OF THE MICROCOMPUTER IN EDUCATION

Apart from the above-mentioned three ways in which the microcomputer can (and should) be used in education, other uses can also be distinguished, for instance for administrative use, computer science, library or media centre, preparation, development of staff, guidance and test item banks. Various publications contain more details about these possible applications, e.g. Mulder (13), Roeks (15) and Watts (22).

As regards the possible administrative applications, Watts points out that the microcomputer can keep a record of all the teacher's and pupils' details (e.g. attendance, school achievement). A well-designed system then has this advantage

that the clerical work of both the principal and the teachers will be appreciably decreased. The microcomputer can also be used to prepare the timetable for the school (22).

It is important however, to note that various authors warn that one microcomputer cannot be used for both administrative and teaching purposes.

5. PROBLEMS SURROUNDING THE INTRODUCTION OF THE MICROCOMPUTER IN EDUCATION

It is important to examine the problems mentioned here, because if the RSA is to use the possibilities offered by the microcomputer successfully, strategies will have to be designed to cope with these problems. These problems are virtually without exception of a universal kind and are described in literature also in respect of the USA. The fact that these same problems are also encountered in the USA, the leading country in the field of the implementation of microcomputers, shows that the development of microtechnology has been so fast that developments in other fields could not keep pace.

5.1 THE DIDACTIC PROBLEM

This problem will not be found under this name in other writings, but is nevertheless related to the last statement made in the preceding paragraph. The development of the microcomputer was so fast that educationists were caught unawares. Various authors, who mostly are not educationists, point to important didactic problems in the implementation of the microcomputer in education.

A few of these are the following:

- What is the (micro)computer's place in the education situation, seen from a didactic perspective?
- What are the most effective strategies for incorporating computer-assisted instruction in other educational strategies (11)?
- What are the most effective computer-assisted educational strategies (11)?
- What detrimental consequences can develop around an excessive use of computer-assisted instruction (11)?
- What effect will computer-assisted instruction have on the social interaction in the classroom (the socializing principle)?
- How will the teacher's role change if the computer instead of the teacher or the library becomes the source of information?
- Problems of a more detailed nature, but which are nevertheless of importance, are for instance the question concerning the importance of things such as colour and animation in the choice of a microcomputer and also whether a printer, for instance, is necessary. These questions have important didactic aspects which have not received attention yet, neither in this country nor overseas.

Braun states that very few people who are involved in education (educationists) devote time to the development of activities related to the computer, while Kurshan makes the important statement that control over microcomputer technology in education will depend on how well instructional designers (didacticians) under-

stand the use of the computer for educational purposes (2, 13). Compare also the following statement by Kurshan: "The instructional designer's responsibilities in this collaborative effort are to understand the basic components of micro-computer hardware and selection, become a literate consumer of microcomputers and assist in the design and implementation of creative instructional programs delivered via microcomputers " (12). There should also not be the slightest doubt that the extent of uninvolved educationists in this problem area, also has an effect on several of the other problems that will still be discussed, such as the lack of useful educationally accountable courseware; the gaps in teacher training in this connection and the illiteracy in regard to the computer which is found among both teachers and pupils.

5.2 TEACHER TRAINING AND ITS RELATION TO THE PROBLEM OF COMPUTER ILLITERACY

This problem already received some attention when the use of the computer for promoting computer literacy was discussed.

Authors such as Dickerson and Pritchard, Kurshan, Gleason and others state the need that exists for teacher training which takes into account the developments in the microcomputer field and its possible applications in education. The micro-computer should be studied systematically in education, so that myths about it can be eliminated and a "science" about the use of the computer in education can be designed (8). Kurshan (13) favours the opinion that the demand for computer-literate students and courses will only increase and that didacticists therefore have to play a major role in the revision, evaluation, design and implementation of such courses.

It will therefore be the educationists' task to define computer literacy, to become computer-literate themselves and to devise specific aims for the use of micro-computers in education (p.29). These activities will necessarily have to become evident first in teacher training and afterwards in the schools.

Dickerson and Pritchard blame educationists for the fact that the "cutting edge" of the literature on the relationship between computer technology and education is not found in educational journals and then warn educationists that, because of this, they have to face the fact that they will make an important contribution to the promotion of computer illiteracy (p.18). "In fact, the implications of computer illiteracy are most serious for the recent graduate of a teacher training institution. Molner (1978-79) notes that educational institutes are creating 'unnecessary human waste' and 'high, unacceptable social and psychological cost' when they graduate students who are not computer-literate" (8).

These statements made in respect of the USA are severe, but understandable if it is taken into consideration that the microcomputer enjoys much wider use in schools in that country than in the RSA. The question is, however, whether the same situation will not develop here if educationists do not enter the field of the microcomputer early and prepare, not only themselves, but also the prospective teachers, for the impact of the computer on the educational situation.

5.3 THE LACK OF COMPUTER COURSEWARE OF HIGH QUALITY

Literature is swamped by statements that refer to this problem. Compare the following statements:

- Little can be done to keep poorly designed (written) computer courseware off the market.
- Most computer courseware is poorly constructed, largely undocumented and only useful to the particular microcomputer for which it was designed.
- Computer courseware that is manufactured commercially does not have an accountable didactic basis and the software that is designed for the different microcomputers is not compatible.

There is unanimity on the fact that the development of computer courseware is an expensive, time-consuming and complex task. Gleason (11) states it clearly in the following words:

"There is far more involved in preparing a good CAI program. It involves careful specifications of objectives, selection of programming strategies, detailed analysis of content structure and sequence, development of pre-tests and post tests, preliminary drafts, revisions, trials, validation and documentation. This is an extremely time-consuming and expensive process, well beyond the capabilities and resources of individuals and even small groups of teachers" (p.12).

There is little doubt that the design of suitable, effective and educationally accountable courseware will determine the success of the microcomputer in education.

5.4 THE PROBLEM REGARDING STANDARDIZATION OF HARDWARE AND SOFTWARE

This problem concerns the great variety of microcomputers presently available on the market of which the user must make a choice, and in conjunction with this, the fact that both the software and the courseware that have been developed can usually not be transferred from one to the other microcomputer system without expensive and time-consuming adaptation. In simple terms this means that programmes written for Apple cannot be used on the Atari or the PET, unless the programme is adapted for this purpose at a fairly high cost (11).

To a certain extent this problem is related to the fact that the different software developed for the mainframe computer to which reference has already been made, e.g. Coursewriter (developed by IBM) TUTOR (developed for the PLATO system), ASET and CAN, with the exception of the last one are all computer-dependent.

Thus there is no standard, high-level complex computer language designed specifically for computer-assisted instruction which is independent of a particular computer. According to Chambers and Sprecher, it is currently one of the most important obstacles to the wide application of computer-assisted instruction in education. These authors think that the development and collective use of quality computer-assisted courseware is the greatest single matter of critical importance at the present time (p. 338).

There are three aspects related to the problem of standardization that must be examined briefly.

- The first is the large number of available microcomputers from which a choice has to be made. The Radio Shack TRS 80, Apple II, IBM personal computer, Commodore PET and the Texas Instruments 99/4 A are all well-known names in this respect, each with its own advantages in matters such as cost, service, available components and the provision of colour, sound and graphs, etc.

- . The second aspect, closely related to the preceding, is the software that has been developed, and which, with a few exceptions as has been stated already, is dependent on the machine. Choosing a particular microcomputer in most cases therefore means choosing specific software and thus the particular advantages and disadvantages attached to it.
- . The third aspect at issue is the variety of instructional (learning) material already available on the market of which most was not designed in an educationally accountable manner. There is a great need to have this material evaluated by expert didacticians for their usefulness in South African schools and educational institutions.

5.5 THE PROBLEM OF COST

Much has been written about this and it is generally agreed that the availability of the microcomputer has placed hardware within the means of educational institutions such as schools. Cost is nevertheless still an important factor contributing to the fact that computer-assisted courseware is not used more in primary and secondary schools. The development of quality courseware is mainly responsible for this, because it is estimated that approximately 50 to 500 hours of preparation is necessary to produce computer-assisted courseware for one hour. Naturally the complexity of the material and the expertise of the people developing the material will determine the time required (Chambers and Sprecher, p.337).

The above once more underlines what has been stated repeatedly, namely that the development of computer-assisted courseware (as well as the evaluation of existing material) is a complex matter that will have to be tackled by experts.

6. CONCLUSION AND DEDUCTIONS

The above paragraphs underline a number of matters. Firstly there can be little doubt that the microcomputer is the educational aid of the future. Dickerson and Pritchard do justice to the possibilities of the microcomputer with the following statement:

"Computers can have an exponentially greater impact than television, due to their interactive nature and storage capabilities, therefore an exponentially greater loss might result if educators, and their students, are not prepared for the future" (p.12).

There are also specific reasons for the current minimal application of the microcomputer in education. They are the following:

- . The lack of involvement of educationists with the resultant gaps in the training of the prospective teacher in computer literacy and the virtual chaos existing in the field of the development of the computer-assisted courseware. It will be essential for the faculties of education of the universities in the RSA to become involved immediately. A didactic justification of the microcomputer in education is a pre-requisite for further meaningful implementation of this valuable medium.

Closely related to the above is the lack of suitable computer-assisted courseware of a high quality. As has been said before, that which is available is of a doubtful quality and will have to be evaluated carefully. Programmes developed overseas, cannot be transferred to South African conditions without more ado. The total

lack of Afrikaans computer-assisted courseware is a matter that should receive urgent attention.

The great expense attached to the introduction of the computer in education has now, to a large extent been reduced to the cost attached to the development of courseware. The development of computer-assisted courseware and the evaluation of the existing will have to receive attention at a high level, and closer co-operation between the authorities and the private sector will probably be of primary importance here.

Apart from the above matters which demand urgent attention, a joint and co-ordinated attempt will have to be made to promote computer literacy among educationists, teachers and pupils.

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THE SPACE SYSTEM

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ABSTRACT

1. Presentation of a computerized video educational system.
2. How it functions.
3. Why it is unique.
4. Advantages over other systems currently in use.
5. Format of course presented.
6. Range of courses currently in use and planned.
7. Objectives.
8. Response of students & general public.

A short movie/video will be shown.

PROVIDING EFFECTIVE AND AFFORDABLE COMPUTER-BASED EDUCATION

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ABSTRACT

To provide useful and economical computer-based education it is important that a variety of people be supportive and satisfies users. Among these users are students, teachers, authors, administrators, researchers, industrial personnel, as well as others in the community.

For the student, the system must be easy to use and must respond quickly and accurately to the students' unique responses. For teachers, the system must provide a method of monitoring and evaluating student progress and a means for communicating the results in useful forms. It should also rapidly facilitate curriculum selection and design. For the author, tools must be provided which make authoring and editing simple. For administrators, the system should provide data processing as well as text editing and other business applications. For researchers, the system should allow large scale modeling and simulation.

In each case one should assume that the computer is being used by a person who is naive about computers, but is an expert in his own field. Providing the software, hardware, and courseware for such a wide range of applications can be a difficult and an expensive task if not properly approached.

This paper discusses the various human and hardware components that must be addressed to provide the needed flexibility while yet developing an efficient and economically viable system.

USER TRAINING FOR THE LIBRARY OF THE FUTURE

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ABSTRACT

The Library of the Future (LOF) is beginning to take shape now and shows all the signs of being largely electronic, at least as far as information storage and retrieval is concerned. The LOF will be part of a global information network, drawing not only on its own internal resources, but also on those of the large networks such as OCLC, the online information vendors such as Lockheed DIALOG and SDC ORBIT, and the videotext suppliers such as PRESTEL and BELTEL. Electronic journals and telefacsimile will be normal components of the LOF.

Telecommunications is the key to the melding of all these components. Global online interaction, teleconferencing, electronic mail, full text retrieval and transmission are all linked via this medium. The LOF user will need to be familiar with these technologies to derive maximum benefit from the available services.

Training of the user is seen as extremely important if the information society is to come to fruition. Initially so-called intermediaries, (i.e. librarians) will have to be trained, but ultimately the end user of information will have to be independent in the use of these media, especially with the introduction of home videotext systems.

It is a perplexing task to talk about training for something which still has to eventuate, because the exact nature of the beast is still unclear and moreover, the future is an unknown quantity. Until fairly recently the future for most of us was George Orwell's 1984. Now, I suspect, the year 2001 has that magic ring to it instead, so let us set our sights some twenty years hence.

My topic is user training for the Library of the Future - LOF as I am going to refer to it. As a first step, let us look at the components that will constitute the LOF. Most of them are already available in one form or another, and are slowly being integrated into general library use.

LOF Components

1 Computer Networks

Librarians and information scientists have long regarded the computer as the means to cope with the information explosion. A great deal has been said and written about library automation, but surprisingly little has in fact been implemented. The microprocessor is about to change this situation dramatically and a computer for every library at last seems to be a practical reality (Hyman, 1981).

The in-house microcomputer will be used for requirements such as catalogues and indexes, accession lists, ad hoc bibliographies, order and acquisition activities, and current awareness bulletins.

However, the major impact of computerisation will be in networking, where libraries will share certain common activities, mainly cataloguing and inter-library loans, on big centralised mainframes such as the one operated by OCLC Inc (Kilgour, 1980; 1981).

In this network more than 7 300 libraries are linked to OCLC's central computer in Columbus, Ohio by 150 000 miles of dedicated telephone circuitry. The online union catalogue contains entries for 6,75 million titles to which are attached more than 80 million locations. Participating libraries are cataloguing more than 65 000 books each day and initiating approximately 4 000 inter-library loans daily.

Funding is at present being sought to implement a similar system in South Africa. The proposed network, to be known as SABINET, will link all South African libraries to provide centralised services (Boshoff, 1982).

2 Online Vendors

Online information retrieval services such as Lockheed DIALOG and SDC ORBIT developed over the last decade. Libraries became increasingly dependent on these retrieval facilities as a fundamental component of their services.

These so-called information wholesalers offer millions of bibliographic references which are immediately accessible in online mode. The services are available virtually on a 24-hour basis for more than six days a week. Because access is billed on a usage basis, even the smallest library can afford to offer sophisticated retrieval facilities. More than this, even the private individual can afford to do his own information searching, provided of course that he had some training in using the systems.

3 Videotex

Videotex is an information service which, with the aid of a telephone and television set, will allow the user to withdraw information from a central computer bank and get the information displayed on the TV screen. As the two basic components are available in most homes, the potential is obvious (Woolfe, 1981).

From the comfort of their homes, users can request information on anything from the latest local and foreign news to travel and entertainment schedules, weather reports, study material, and eventually any information available in books and libraries.

Videotex systems are being developed in many countries, usually by the PTTs, such as Prestel in the UK, Bildschirmtext in West Germany, and Beltel by the South African Post Office.

More so even than the online vendors, the videotex systems bring information directly to the information user, suggesting that the LOF is going to be a much more decentralised activity than the library as we know it today.

4 Word Processing

In the general sense, word processing (WP) covers any method that moves words from one location to another, e.g. telex, facsimile, photocopiers, text editors, even computers. In the modern sense, WP is taken to be more directly associated with text editing electronic devices (Koeneké, 1979).

A new generation of optical character recognition devices that are able to process character sets of a larger variety than those available today and a multiplicity of portable data input devices are being developed. The time is rapidly approaching that these devices, together with word processors, will enable all non-numeric data to be processed in parallel and/or in conjunction with the numeric variety (Paterson, 1980).

Communication word processing, commonly referred to as 'electronic mail', by permitting extensive peripheral sharing, and allowing operators to recall documents stored on other connected systems, will make full text retrieval a commonplace occurrence in the LOF. (Lloyd, 1979; Farrell, 1979). Some

libraries are already using electronic mail services to handle inter-library loans and for resource sharing (Housman, 1981)

Linking the Components

It should be clear that the LOF will, in some respects at least, differ markedly from the library of today. Lancaster predicts that by 2001 we will rely more heavily on electronic information and communication sources than on traditional print media (Lancaster, 1978a; 1978b).

The 'information highways' (Thompson, 1981), by which it is possible to meld the different components of the LOF, are firmly based on telecommunications, shrinking the world to a global village in terms of information resources.

By this means, the LOF will use online information systems and services to receive and transmit mail; compare reports; transmit reports for review; transmit papers to electronic journals; communicate with editors and referees; communicate with information specialists; search data bases and data banks of all kinds; request, receive and read text, and build and maintain information files (Hoover, 1980).

It is clear that the LOF will be very much part of what James Martin calls the 'wired society' (Martin, 1978). Before this can truly come about, we need an essential 'bonding agent' to bring together the user (of information), the information, the computing and the communications technology (Price, 1981).

User Training Implications

The technology for the LOF is making rapid progress. The advantages of technological convergence will be delayed unless people, experience and education keep pace. There is a need for what has been termed 'convergence technologists' (MONITOR, 1982).

The LOF with its easy access to global data bases and information banks, will greatly change what is necessary for users to know. A professional person need not be a storehouse of facts and know-how, as he can easily obtain the information he needs from the LOF. Marvin Adelson has said that "The changeability of the environment and the enormous growing mass of knowledge are leading to a shift in emphasis away from attempting to learn what is known in anticipation of its possible later value, toward learning the means of finding out what one has to know when the need arises" (Adelson, 1972).

As James Martin points out, education in technology is undergoing a transition. Many universities traditionally used to emphasize know-how; today there is more emphasis on science and the development of mental agility, which will produce graduates who continue to grow professionally throughout their lifetimes. This will make them better able to survive the increased complexity and future shock and better able to learn how to make use of new communication facilities and rapidly changing technology (Martin, 1978,).

Telecommunications, computerisation, and machine intelligence will bring about entirely different search patterns so that many persons can practice three or four careers in a lifetime. Electronics will create both the need and the tools to make this possible.

The LOF can be perceived as having several important attractions: it offers a single access point to diverse sources of information which will be up to date and available round the clock. Some general concerns will need to be overcome, however, primarily the requirement to develop new skills to use a system which is complex in spite of its aim of design simplicity.

The view has been expressed that only one consideration stands in the way of this information revolution: the complete lack at this time of information scientists with the multiple levels of systems and host-organisation understanding to make it all happen painlessly (Paterson, 1980).

According to Kent the past ten years have seen no advance in our training about how to organise information or how to retrieve it. As he puts it, we remain the prisoners of inverted files and Boolean operators (Kent, 1981). As a consequence we shall see the recreation of a much more direct link between those who create information and those who use it, with the elimination of the intermediary or information middle-man.

A somewhat different opinion is expressed by Hoover on the basis that the number of online sources available through a single terminal will be so vast, diverse and complex that professional guides and consultants will be needed to help users of the LOF through the maze (Hoover, 1980). The electronic librarians of the future will be able to work out of offices and homes, free from large collections of physical journals, books and other printed artifacts (Van Grassek, 1980).

Kent further predicts that the information specialist in the electronic age will provide the following services:

Furnish information on demand

Guide users to and through
available online resources

Provide training in the use of
electronic resources

Assist in the development of
personal information files

Advise on the development of
personal information files

Organize and control electronic
mail files in organizations

Whereas the librarian of today, as well as the so-called intermediary or information middle-man, plays a much more active role in locating printed materials containing information, it can be seen that in the LOF he will be much more of a consultant and advisor. The end-user of information presents a different and perhaps more difficult training problem than the information professional (Caroso, 1978). To make the learning of the new resource, the LOF online data base, as attractive and rewarding as possible means that we have to stress those features of the online systems which were originally seen as their greatest strength. Those features are availability in the intimacy of the laboratory or study without scheduling or travelling limitation, with immediate feedback and guidance in the search process.

The development of information technology is changing the requirements for education. According to Barron and Curnow of Sussex University, it is of little use to provide narrow courses in computing or in electronics or telecommunications when the synthesis of these subjects is required to provide degree courses of greater relevance to the future (Barron, 1979). They also question the extent to which the current specialist education really has much relevance to the future. What is required is not so much specialist teaching in the area of computing and information technology, as the teaching of the concepts of computing and programming techniques to a much greater proportion of university under-graduates. It should perhaps be a target that every graduate should be capable of using computer systems and has a thorough understanding of their potential.

The LOF librarian may well find himself in the position of becoming almost a full-time trainer in having to teach others how to use online systems. In order to teach someone successfully how to use an online system, you must first educate the person in the information fundamentals, then you must persuade him that online offers him something he can not get anywhere else more cheaply, easily and quickly. Then, finally, you can train him in the use of a particular system (RAITT, 1981).

This changing role of the information provider is seen as a challenge by Mary Berger, immediate past president of the American Society for Information Science: "We can make a valuable contribution in this information age, by providing access to services, by identifying services that are needed and do not exist, and by evaluating the effectiveness of these services against user needs" (Berger, 1981).

Berger goes on to say that the information worker, or 'electronic librarian', will be in an excellent position to educate all types of users. "We can educate researchers in all disciplines about areas requiring research; we can educate the information providers to the users' needs from our perspective, we can educate the users to the availability of information, and we can educate the lawmakers to the impact of their decisions on both users and providers of information. Most importantly, we can educate the users how to use the products and services themselves by teaching them to use the blossoming technology".

Perhaps the task will not be as daunting as it seems now. Today's children are already being prepared for the electronic age - locally, in the Sea Point Primary School, sub B pupils are introduced to computers by using Apple computers to run programmes which reinforce basic mathematics drill. Electronic tools and services are being purchased and used almost without question by today's youth, who find in them entertainment and productive capabilities. In twenty years' time, all of the electronic information media will be as familiar to them as tape recorders and record players are to our generation. User training for the library of the future could in fact be very exciting.

One cannot conclude a discussion such as this without referring to what has been called the social cost of information technology (Henderson, 1979). Society is depending more and more on comprehensive and readily available information, which in the LOF will reside almost fully in electronic form. The information society will be technology dependent.

This situation will bring about problems that are not entirely technological, but fall more in the area of bureau adaptation, requiring the attention of specialists in social, behavioural and management sciences. Above all, the educator will have to play a meaningful role, starting now, in preparing the user to make meaningful use of the library of the future.

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VIDEOTEX AND EDUCATION

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ABSTRACT

Videotex is essentially cheap computing, using a TV screen display, telephone line access (on dial-up) or broadcast transmission. There are a variety of systems in operation, the most suitable for education being the North American versions, e.g. Telidon.

Several specific options are applicable to education: audio-graphic conferencing, graphic 'tape-slide', data-base access for information, networking of information and telesoftware, subtitling of video programmes. South Africa has two systems, INFO and Beltel, which both offer some potential education use.

VIDEOTEX AND EDUCATIONINTRODUCTION

Videotex is essentially cheap computing, or at least hopes to be so. That has advantages and drawbacks. The terminal used is the TV screen, which is less sophisticated than other VDUs, and less expensive. The graphics capability varies, but is adequate for education, with some exceptions. Transmission is slow, so that it can use cheap dial-up telephone lines, and in fact videotex systems invariably operate all calls on a local-charge billing, independent of the actual distance involved. The software and terminal access are quite crude in the most basic systems, to allow for user-friendliness.

Many systems are possible, but the basic classification is on transmission lines: broadcast systems are called Teletext, and interactive, telephone-line systems are called Viewdata, or sometimes Videotex. A variety of transmission modes is possible. Both forms of videotex offer new facilities, but they will have to live and compete with a variety of other new facilities which are also trying to make a place for themselves on the market. In the long term, especially in South Africa it is long term, videotex will become part of what will be the automated home, as well as the automated office. Either way, videotex must be seen as one option among many.

FACILITIES

There are quite a few systems in operation. The British (Prestel), the French (Antiope), the Canadian (Telidon), the Japanese (Captain) and others. There are in effect only two standards today, the European CEPT, and the North American Telidon, which has a big brother called AT&T, a slightly improved version of Telidon which throws in CEPT as well. The basic differences between the systems is the graphics capabilities.

CEPT uses alphamosaics, i.e. small blocks make up the pictures. Telidon uses computer graphics, namely PDI or picture description instructions. These allow much better curves and detail, and the coding in terms of geometric primitives allows the system a large measure of upwards compatibility. This is not true of CEPT, which will fall behind the inevitable advances in display technology. Telidon can draw much better and more detailed maps, diagrams and pictures of people. It is a far superior audio-visual medium, and probably perceptually much more user-friendly even for pure information access.

Print-out facilities are available, but once again the crudity of the CEPT system is a disadvantage, and it shows in the print-outs.

Lets take a look at the Telidon graphics. They are based on the primitives: line, arc, polygon and rectangle. There is a very large colour range, including half-tones. Very realistic drawings of people are possible, and it has a useful diagrammatic ability. In the end one has to decide, as with all computer purchases, whether the particular option is both cheap enough and good enough at the same time. And it is possible to do the same on the CEPT system, although one has to add on to the basic system, which is confined to mosaic graphics. The Open University in the UK is in fact doing just that, their Cyclops system is a PDI graphics form of the much cruder Prestel.

The graphics facilities are nothing like those on sophisticated computer-aided design systems, but they can be used for educational purposes. After all, the resolution of the video programme, that is very widely used, is very poor compared to Telidon graphics. Important in terms of cost-effectiveness is the ability to store an audio track and graphics and text in videotex form on an ordinary audio cassette tape. The cost of reproducing tape-slide programmes is very much higher than the cost of reproducing a stereo audio cassette tape!

Another very cost-effective application is conferencing. It should be possible to conference from a variety of centres on videotex, on ordinary dial-up telephone lines. This is much more useful than the telephone-only conferencing and much cheaper than the television conferencing presently offered at between R500 and R1000 per hour. It amounts to what could be called interactive faximile, as you can draw on one screen, and have the image come up on others in other centres simultaneously. Of course this can be done with a multitude of other systems, but probably not as cost-effectively.

The question of languages arises in any educational use, and videotex has the capability of using more than one language, with different character sets. The character sets can be part of the terminal, or they can be down line loaded as DRCS or dynamically redefinable character sets.

INPUT AND RETRIEVAL

The data base on most videotex systems is a 'tree-structure' consisting of numerical menu choices leading down to information pages. It is probably better to think of the structure in terms of wheels, where the central index is the centre of the wheel, and by a numeric menu choice you go out to another index node on the rim of the wheel, and so on.

This numerical menu based system is accessed by means of a numerical keypad, with a few control keys. It is simple and crude, and is designed to be user-friendly. It is possible, often on the same data base, to access videotex systems

via full keyboard keywording. The French have concentrated on this type of system, and have designed a number of rather elegant terminals.

The basic videotex system is, as its name suggests, tied to the TV screen, and print-out facilities have to be added on. But there is no reason why the same should not be done on an acoustic coupler print-out, which is a cheaper option if one is prepared to forego the colour and graphics (the latter do not always look very good on cheap printers).

The user-friendliness of the videotex system, i.e. numerical menu selection via a keypad is complemented by a page number access, for those people who want to make regular use of particular parts of the data base. This is usually offered on systems which have keywording as well. Another very useful way of assuring the user of user-dumb and user-friendly access is to offer access via a voice telephone call to a telegirl, who keys into the terminal in front of her, and tells you the answer on the telephone. This is in fact a much more sensible way of dealing with the problem of user stupidity and terminal phobia than the standard videotex method, which compromises on keywording in order to offer a numerical only access.

If one keyed into a data base one might go through a menu selection of 1 general index, 2 agricultural index, 3 livestock index, or wheat index, 4 the actual live-stock or wheat trading prices that you wanted. That doesn't take too long, but it doesn't compare with keywording. More important, systems which are based on keywording normally have cross-indexing as a basic part of the design. On the other hand, tree-structured numeric menus usually don't, especially as the sections of the data base are sold, or hired, to Information Providers, (IPs) to operate as isolated entities. It is not in their interests to cross-index to what are competitors. From the point of view of the user, be they household or business, a comprehensive and cross-indexed system is far superior.

Part of the problem of some videotex systems is the fact that they are tied to broadcast videotex (teletext) use on the same standard. And although it is possible to link up broadcast transmission with telephone line request, this is not usually done. Teletext is normally broadcast only, and clearly the use of a non-interactive system cannot have keywording. This is the case in the UK, where the format of videotex is closely tied to teletext use. Designing the system from the point of view of multiple transmission channel transparency, as is the case in France, is a much more sensible option.

SOUTH AFRICA

In South Africa the Post Office (SAPO) is currently starting a trial called Beltel. Beltel is based on the West German model of videotex, although the software is English. Access is numerical keypad, via numerical menus. The actual service should start only in about 1985.

The SABC is not interested in a system at present, as they are caught up in the expansion of TV2&3. They might be more interested in about 1986. The possible use of teletext depends very much on the enthusiasm of the systems operator (SO). The basic system, which merely inserts data into spare capacity on the normal TV signal, can carry only about 200-300 pages, and each page is only about 80 to 100 words. News, programme schedules and so on can be carried.

However, that uses only two of the spare lines, and is broadcast cyclically every 4s. That can be multiplied by 150, for full channel use, and you then have a transmission capacity of about 30 000 pages per four seconds. Each page can be time coded, and numbered, and the TV channel in the non-TV programme time can be a vast archival source broadcasting 450 000 pages per hour. Those pages can be information, including indexing, or just software. Either way the educational system, with its mounds of paper going back and forth, can benefit.

Teletext's most impressive use at present is optional subtitling. Because the standard teletext signal is inserted into the hidden part of the TV signal, the standard viewer will not see subtitles. However, someone with a decoder will be able to choose which of up to eight subtitle languages they want and have them displayed on screen, along with the video and sound signal. This is a tremendous advance for the deaf as well as for the thousands of people who eagerly try to pick up another language by watching TV programmes. The deaf are estimated at about 8 (or more) percent of the population, and they deserve this (very cheap) improvement to TV to allow them access to a major mass medium.

There is another information system in South Africa, which is not a videotex system in the same sense as Beltel, but is perhaps more similar to the French or Danish models. The INFO system currently runs a telephone service, on which you can get information by dialing up, and talking to a telegirl. This is a very good solution to the problem of user-friendliness, as the telegirl keys into a powerful keywording system. If you want your own direct access, you should be able to use an acoustic coupler terminal, and access the data base direct. At the time of writing SAPO intends to cut off this service, (INFO-MAX), but they could be slitting their own throats. They would in fact benefit by letting this service operate, but one wonders whether they will see it this way.

The INFO system is far more versatile than Beltel, using more powerful and faster searches. It also uses indirect financing, where the IP (Information Provider) pays the costs, and the user, only line charges, (and terminal purchase if needed). This is in contrast to Beltel which charges for each bit of information received - and there is no guarantee that direct costing will work - it certainly hasn't worked yet in the UK for Prestel.

CONCLUSION

Videotex has the potential to assist education in South Africa. This depends on a good graphics system, which is upward compatible, i.e. Telidon. Beltel is not suitable. It also depends on full use of teletext, including full-channel broadcasting of data, and the SABC might show an interest around 1986. Subtitling is very cheap, and the SABC can be expected to introduce this some time. Videotex can also provide information and network software as back-up for education in general and for computer-aided programs. It can usefully provide an audio-graphics conferencing facility, and a very good graphics version of tape-slide, on the cheap audio cassette storage medium. SAPO policy on INFO and on possible use of other systems like Telidon could be far more crucial to the use of videotex for education than any of the characteristics of videotex systems themselves.

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USING COMPUTER-AIDED INSTRUCTION TO TRAIN ADMINISTRATIVE PERSONNEL

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ABSTRACT

This paper discusses the problems and possible solutions in training administrative personnel in the Computer Industry. The emphasis is the use of Computer-Aided Instruction (CAI) in training administrative staff in obtaining knowledge about the basic requirements of their job. A suggested training structure is outlined. The writing or authoring of CAI courses with a new authoring language, Instructional Module Generator (IMG), is also mentioned. The positive results of this training programme are noted. All comments and opinions in this paper are those of the author and not of the IBM Company.

USING COMPUTER AIDED INSTRUCTION TOTRAINADMINISTRATIVE PERSONNEL

1. Introduction.
2. The Training Problem.
3. The Solution : A Structured Training Programme.
 - Level 1 - Theoretical
 - Level 2 - Experience
 - Level 3 - Classroom
 - Level 4 - On-the-job
4. Computers and Administrative Training.
5. Authoring Courses.
6. Results.
7. References.

1. INTRODUCTION

This paper covers the use of Computer Aided Instruction (CAI) to train administrative personnel in the Computer Industry in South Africa. A successful systems approach to training in Administration will be described. We shall also take a brief look at the relatively new art or science, the writing or "authoring" of CAI courses. New developments in the data processing software area make the authoring of CAI courses in English and not in computer jargon a possibility.

The views expressed in this paper are from my own experience, and not necessarily the views of the Company.

2. THE TRAINING PROBLEM

Most companies in South Africa have experienced or still are experiencing serious problems in obtaining trained staff. In our industry, the Data Processing Industry, we hire administrative people with bachelor degrees or other professional qualifications. These administrative hires are taught product knowledge (both hardware and software); how to operate complex data processing systems to order, process and install our equipment with our customers; how to control the accounting procedures and practices for sound business management and customer satisfaction. The question arises how best to teach all this information and skill in the shortest reasonable time. Specific problems that confronted us were:

- New hires have different cultural and business backgrounds,
- hiring was and still is done when people leave the Company or when they move to different areas within the Company (managers find it difficult to forecast their staff changes),
- new hires have usually little experience of computers or data processing systems,
- staggered hiring resulted in employees waiting for scheduled training or instructors having too small a class,
- new hires, assigned to experienced administrators, were not learning our complex business effectively,
- low morale, low productivity and poor motivation began to show.

In looking for a solution to our problems to get new people trained quickly and effectively, we came across the use of Computer Based Training (CBT) courses developed for Administration and used extensively by our Company in Canada. We decided to pilot test some Canadian courses in Administration in South Africa.

3. THE SOLUTION: A STRUCTURED TRAINING PROGRAMME

Before installing the CBT courses we structured our training into four levels. This training approach is based on sound principles of Empirical Education.⁽¹⁾

We decided to teach the theory of our business via the terminal or video display unit (VDU). The experience needed to clarify the theory was provided in the actual work situation. Classroom instruction and practical exercises were used to broaden one's knowledge and develop additional skills to do the work. Finally, the trainee was ready for his or her on-the-job training with minimum supervision.

However, let us look at each of these areas in greater detail but more especially the theoretical side of our training.

LEVEL 1 - THEORETICAL:

As stated, most of our Administrative trainees have a bachelor's degree or are studying towards one. However, a common missing factor was that among the new graduates few had ever developed the skill to operate a terminal, or "screen". Our training approach started with the familiar "simple to complex", 'known to the unknown', etc, teaching and learning approaches.⁽²⁾

Our first Computer Aided Instruction Course taught not only the theory of terminal usage but it also allowed the student to use the actual "keyboard" of the terminal. In fact, most learning in the CAI environment assumes that the learner is familiar with the basic functions of a key-board. As the student was learning that the terminal could be both an "input" (sender of messages) and an "output" (receiver of messages) unit, he or she was actually using the various functions of the keyboard. The duration of this and all our CAI courses varied from student to student, depending upon their aptitude and past experience. (See Table 1 for study time taken for each course). At the end of the study period, the students were far more confident with the basic keyboard functions than they could ever imagine. A practical test, also on the screen, concluded the students learning of the VDU.

This introductory terminal course officially called the "3270 Operator Training Course"⁽³⁾ is available as a standard Interactive Training product from IBM.

After the terminal course, the student moved on to learning about the "royal" computer itself. Now the student was ready to learn what is a computer and how does it work. Perhaps one can call this course a Computer Managed Instruction (CMI) course because more use was made of a written text book with questions and explanations being offered on the "screen". One can say that the "screen" guided the student through the book and therefore the course. See Table 1 for duration.

This course too is a standard product, officially called "Introducing ... the Computer",⁽⁴⁾

Having given the student knowledge about the operations of the terminal and the computer, he or she was now ready to learn about the Company.

LEVEL 1 - THEORETICAL (cont.)

With many new people joining the Company and particularly Administration, I authored a CAI course teaching about the Company organisation. IBM makes necessary organisational changes to meet the changing business and customer requirements. Hence a terminal course was the answer to teach such a changing topic. At the conclusion of this course, each person knew the key people in our management structure, how the Company was managed and the numerous other departments that an Admin person would need to know. The new student often exclaimed at the conclusion of this course, "I now know where I belong". And what a fine feeling to have after having been with the Company only a few days. See Table 1 for duration.

We then introduced the student to CAI courses which covered specialised fields in our Administration. These courses are Company Administration, Managing Computer Orders, and Contracts. See Table 1 for duration.

I would like to point out that these courses are the basic ones a new trainee would take. A trainee moving from some other area in the Company into Administration need select only pertinent courses.

TABLE 1

(Duration, in hours, of each CAI course described in Level 1 - Theoretical).

<u>Name of course</u>	<u>Range</u>	<u>Norm</u>
"3270 Operator Training"	2 - 8	5
"Introducing the Computer"	2 - 10	7
IBM South Africa	1 - 4	1½
Company Administration	5 - 16	12
Managing Computer Orders	4 - 10	5
Contracts	2 - 6	4

NOTE:

1. The "Range" figures illustrate the great advantage a student has of progressing at his/her own speed.
2. Most students fall into the "Norm" area, the typical statistical "bell" distribution.

LEVEL 2 - EXPERIENCE

Trainees can interrupt their CAI training (Level 1) by visiting their actual work station to perform simple duties but most students choose first to complete their selection of Computer Based Training Courses.

Once the trainee completes this theoretical module he is ready to gain experience and broaden his insight into what he has been learning. The student works in his future work environment as an assistant to a more experienced administrator. This could include doing tasks which help add meaning to his previous terminal work. One could refer to this activity as limited on-the-job training.

LEVEL 3 - CLASSROOM

Conventional classroom instruction follows Level 2. Now the student broadens his prior learning and develops additional skills to do his ultimate job. He attends a variety of courses which round-off his basic training.

This employee training covers business practices, legal requirements of the business, data processing products and services, accounting requirements, administering a complex order system, and developing skills to handle customer problems and other business skills.

The duration of these courses depends upon the subject matter. Some courses are only one or two days in length, others are up to two weeks in duration because of their complexity.

LEVEL 4 - ON-THE-JOB

The trainee is now ready to receive his own "territory". This usually includes several customer accounts and their respective sales personnel. The trainee may still refer to a more senior administrator for guidance and help when more complex situations or problems arise.

4. COMPUTERS AND ADMINISTRATIVE TRAINING

This paper illustrates the point that the theoretical aspects and simulated administrative tasks can be taught via the CAI method. No attempt is made to decry the role of the instructor. A good instructor is vital in any training situation and especially in the field of Administration. Classroom and other group exercises certainly have their place in such a training programme as outlined in this paper.

There are important considerations for a successful front end theoretical CAI approach. These should include at least some if not all of the following:

4. COMPUTERS AND ADMINISTRATIVE TRAINING (cont.)

- A stable and reliable data processing hardware and software system and support;
- terminal response times of a few seconds, otherwise the students' concentration wanes and learning decreases;
- management commitment to the whole CAI project;
- a reasonably quiet environment for students to learn (we have a dedicated Admin CBT Centre);
- system availability of nearly 100% (ours is available for 8 - 12 hours per day);
- someone with enough motivation to make it all happen.

I would also recommend that the novice first use existing CAI courses to gain experience, and then start looking at the question of authoring his own courses. Good authoring of courses is not as easy as it initially appears; it is as important as a good lecturer.⁽⁵⁾

5. AUTHORING COURSES

IBM markets several different types of authoring languages. The latest one called Instructional Module Generation (IMG) which has been developed in France is the one I would like to discuss.

Some special features of IMG ⁽⁶⁾ are:

- The course author requires no prior knowledge of data processing terminology, commands are in simple English;
- One can learn the basics of IMG quickly and start using the commands immediately;
- It is interactive and prompts the author for key steps when authoring;
- It works online, allowing the author to try out and modify the material just entered;
- It allows all lines of the screen to be used freely for entering information;
- All course housekeeping is done automatically after modifications have been made;
- Depending upon one's prior knowledge of IMG and subject matter, it takes about 20 - 40 hours to author a 1 - 2 hour CAI course.

From the student's point of view, besides having the familiar CAI features, IMG allows the student to progress at the rate of the student's results. The student can also stop in the course at certain points and branch to other subjects and then return to the original point of study.

6. RESULTS

CAI helped us overcome the problems mentioned earlier. (See Item 2, The Training Problem). Training is modular with students selecting those modules he needs. Many different CAI courses can be offered as and when needed. Students can start training immediately, progress at their own pace and review material as needed.

Instructors have more time to perform more productive work, the updating of courses is done centrally and with ease.

The students enjoy this method of training; most prefer the CAI method to the classroom approach if the subject matter is suitable for Computer Assisted Instruction.

New Administrators are now trained in about one half of the time taken when no Computer Assisted Learning programmes were used.

Even though CAI courses do not get the 'flu (like human instructors), etc., yet these are certainly not without their pain and suffering. If one considers all aspects of training, no fair sized business today can afford not to be without some type of CAI training.

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COMPUTER AIDED-INSTRUCTION IN ESCOM

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ABSTRACT

Escom has decided to buy the PLATO system to cope with its need for trained personnel caused by the growing demand for electricity.

Mechanisation of training offers an alternative to increasing the number of instructors.

Implementation problems:

1. Selecting and adapting appropriate material.
2. Obtaining off-line material.
3. Availability and quality of post office data lines.
4. Computer-phobia.

Training has to be organised and courses registered.

PLATO can increase ESCOM's instruction time by 26% while increasing the budget by 14%, can be used for EDCO -a data processing system -and for psychometric testing.

ESCOM has decided to develop in-house lessons after conducting needs analyses.

COMPUTER-AIDED INSTRUCTION IN ESCOM

ESCOM has decided to buy the PLATO system in 1981, after evaluating it for two years.

1 THE REASONS FOR BUYING THE SYSTEM

To be able to cope with the growth rate of 9% in the need for electricity, ESCOM will have to double its production by the year 1990. To enable ESCOM to meet this goal, it will not only be necessary to increase its facilities, but also to increase the number of people it employs from 47 000 to 90 000. This means a growth rate of 6% per year in the number of people employed. South Africa is very rich in natural resources, but there is a scarcity of human resources. In the past it has been possible to recruit trained staff overseas as the need arose. This source is dwindling and cannot supply all our needs. On the other hand, the growth rate in the number of skilled people in this country is not fast enough to meet the demand. The only solution is to speed up the training of unskilled people. This solution also has its problems. It is estimated that to meet the requirements of increased training, ESCOM would have to increase the number of instructors from the present number of 93 to 334. Since we already have a shortage of 41 instructors from 1981, it is doubtful whether we will be able to meet this objective. If it is possible to supply the shortage of instructors for each year as the need arises, we will have 106 instructor vacancies to fill in 1990. It is clear that we have a problem.

2. WHICH SOLUTIONS WERE CONSIDERED?

- a) Increasing the number of instructors. This solution holds the problems already pointed out.
- b) More facilities. This solution cannot solve the problem in the short term. Erecting new facilities is a slow process.

It is also very expensive, since the training in ESCOM is mainly of a technical nature and expensive equipment is involved. Moreover, only a limited number of students can be handled by a single instructor and an increase in facilities without a corresponding increase in the number of instructors will be no solution at all!

- c) Decentralisation. This requires more instructors and more facilities.
- d) Individualisation of courses. Criterion-Referenced Instruction - This takes up a lot of the time of instructors, who already have a heavy workload, since the courses have to be rewritten.

Selfstudy - supervisors are not always available to help the students. This leads to loss of time and much slower training of people. In addition, the supervisors are not very keen to mark the worksheets of the students, since they have other work to cope with.

It is also difficult to monitor the progress of students, and they are not very well motivated. We all know how difficult it is to study on your own!

- e) Mechanisation of training - ESCOM considered two alternatives: micro computers and a time-sharing system. At the time of the investigation, the micro computers were not well developed. A time-sharing system, and specifically the PLATO system, was very attractive because ESCOM had spare capacity on its Cyber machine. At this stage of the investigation, PLATO had been under development for some 20 years and was thought to offer the best solution.

Not only were thousands of hours of lesson material available, but the touch-active screen made the system easy to use for users who cannot type!

ESCOM went ahead and installed the PLATO system on a trial basis for a period of two years. After the two-year period, it was decided to implement the system on a large scale throughout ESCOM.

The plan at the moment is to install terminals at sixty different sites. These sites are spread over the whole of South Africa. PLATO terminals will be installed at places such as de Aar and Colesberg.

The budget for the allocation of terminals is:

- | | |
|---------------------------------|--------|
| 1. Training centres: | 8 each |
| 2. Large power stations: | 5 each |
| 3. Distribution centre offices: | 2 each |

3. PRACTICAL PROBLEMS IN IMPLEMENTING THE PLATO SYSTEM

- a) Selection from available course material. Here we have had quite a number of problems. The course material must be adapted to suit South African conditions and traditions and must be translated. Unfortunately, cooperation from Control Data in this respect has not been forthcoming. Control Data undertook to obtain the password and permission to adapt from the author for selected lessons. This has not happened. The result is that lessons which are urgently needed in ESCOM, but which use American symbols, cannot be used. Out of the approximately 3 000 lessons 250 were selected. ESCOM has the in-house problem of obtaining subject matter specialists to evaluate possible lessons. These people are extremely busy and it is difficult to persuade them to spend time in front of a terminal.

A further problem in the field of selection of courseware is the fact that courses are developed at a rate of approximately 80 hours per week all over the world. We do not have access to these newly developed courses and cannot make use of them. A clearing house of newly developed courses would clearly be useful.

- b) Another problem we have experienced is that of obtaining course material for selected courses. It takes up to six months to obtain off-line material from America. An obvious solution to this problem would be for Control Data to carry a minimum stock of selected course material in South Africa.
- c) A more local problem is the availability and quality of data lines from our General Post Office. There is a long waiting period after application for such a data line. When the line is eventually allocated, the quality is often poor. Control Data has promised to install an ASCII-protocol in the near future, which will make the PLATO system less susceptible to poor-quality lines. Let us hope that this will be done soon and that it will solve some of our problems.
- d) We have also experienced and are still experiencing a computer-phobia problem. This problem can be subdivided into two main areas. One area comprises the potential students, who are afraid that they will do something wrong, and the other group consists of instructors who fail to see the system as an aid; they see it rather as a competitor. To solve this problem we have had to embark on an educational program, with considerable success.

4. ORGANISATION OF TRAINING

Even with a mechanised system of training such as PLATO, the training does not happen by itself. The training still has to be organised and scheduled. We have formalised the training on PLATO to such an extent that a course must be registered with ESCOM Education Department before a student will be allowed to take the course. He also needs to have a completed form signed by his immediate supervisor. With the registration of a course, the off-line materials are ordered and kept at Education Department untill needed.

A system of booking terminals for specific students has been implemented. We also have a kardex filing system to keep track of the off-line materials at sixty sites. The persons who will be administering PLATO at the site will be trained on a two-day course in Johannesburg.

5. ADVANTAGES OF THE PLATO SYSTEM

- a) The PLATO system will without extra personnel, increase the amount of instruction time in ESCOM by 26%. This is based on an average usage of only four hours per terminal per day. The increase will be achieved with an increase in budget of only 14%. This advantage is over and above all the usual advantages of CAI and the up to 40% saving in time achieved with the CAI system.
- b) The next great advantage of the PLATO system to ESCOM is the use of the system to develop the EDCO system. This is a complete data processing system for Education Department. The system will carry details of all courses, PLATO or other, will handle the scheduling of courses, student bookings on courses, will keep complete student records, and will generate the necessary reports, as well as printing certificates for successful students.
- c) ESCOM, in cooperation with the National Institute of Personnel Research, and with the aid of Control Data, has developed a system of Psychometric Testing on PLATO. This has numerous advantages, inter alia decentralisation of testing. PLATO also marks the test, with a consequent time saving of, for example, 1 hour on the 16PF test. Psychometric testing can now be done at sixty sites throughout the Republic and we are hoping that, when the free-standing PLATO system becomes available, it will be possible to equip a truck with terminals and a power generator, and in this manner to take our psychometric testing equipment to any place in South Africa or even into a neighbouring country and to be completely independent of power or communication systems.

6. CONCLUSION

We have found that the PLATO system has tremendous capabilities and can offer a solution to our training problems. We do feel, however, that the most effective way to use the PLATO system would be to utilise lesson material that has been developed in ESCOM after an in depth needs analysis. It would therefore be necessary to have a sufficient number of TUTOR authors employed in developing courses.

The disadvantage of this strategy is that it is fairly expensive to develop your own courses, but this applies to all course development. The advantage is that a team of specialists in the development field will be brought together who are not only TUTOR authors, but also educationists, thus ensuring course material of a high educational standard.

ESCOM has purchased the PLATO system, and in spite of those problems to which we are still seeking solutions, we are convinced that this system can solve most of our training problems.

CYBERCOM ASSISTED LEARNING IN COMMERCE AND INDUSTRY - A CASE STUDY

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ABSTRACT

Cybercom assisted learning in Commerce and Industry.

A case study.

1. The paper discusses a systems approach to training and how this approach is used together with a computer based learning system, to establish and meet the training needs in a typical South African Company with multi-national personnel.
2. Procedures
 - *2.1 Need Analysis
 - 2.2 Training Analysis
 - 2.3 Synthesis and validation design
 - 2.4 Implementation
3. The paper will include curriculum design with reference to the requirements of the In-Service Training Act.
4. The 3M training centre:- A case study.
 - 4.1 Aims of education and training in 3M
 - 4.2 Use of a teaching - learning system
 - 4.3 Evaluation of the system
 - 4.4 Beyond industrial training

1. INTRODUCTION

In business we want results. There must be a return on investment. If we invest money in training we want results. These results will be in the form of competently trained personnel, higher productivity, and in the final analysis a return on investment in rands and cents.

We are therefore talking about Effective Training. So great is the need in S.A. that the government has given Tax incentives for this purpose. They also want a return on investment - so does the taxpayer. So again we are talking about effective training.

Effectiveness has become the central issue, and for this reason a systematic and integrated approach has become essential (1)

In the 80's we are experiencing the evolution of Training Technology three. Described by I.K. Davies as a combination of hardware and software approaches i.e. of Training Technology one and two. It takes a systematic and integrated approach, and applies behavioural science to the problems of both learning and teaching. In this sense it is concerned with a true training ecology and has been brought about by the application of modern theories of organisation to the design of training programmes. (2)

It offers a systematic approach to problems of training design.

It is this systems approach to course design that the Department of Manpower, Industrial Training Section, support.

It is not the intention of this paper to describe what the systems approach consists of as various models have been discussed to date (3), but to look at the requirements and criteria required to approve a training scheme in terms of the Act so that companies who use computer based learning systems may benefit from the 200% Tax Concessions.

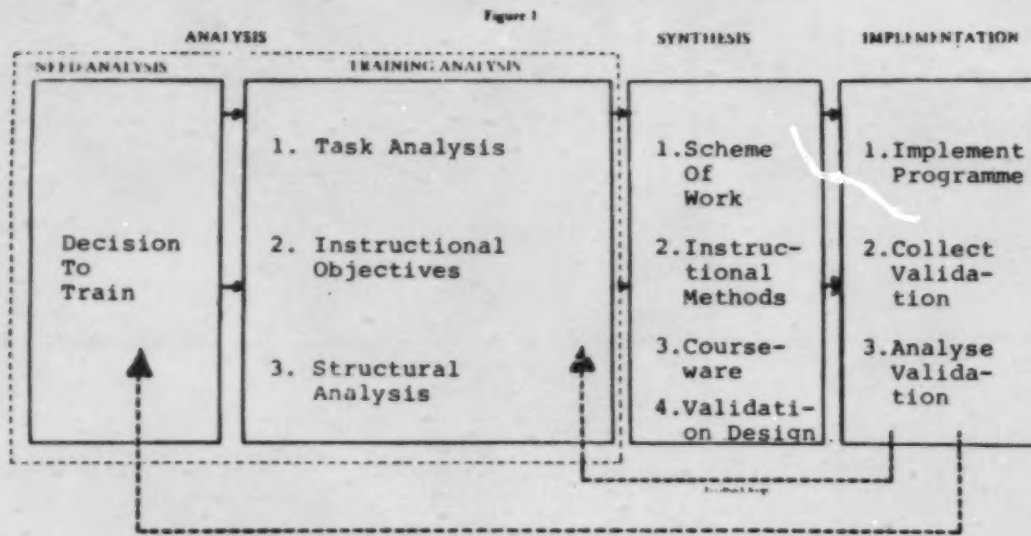
Essentially we are therefore not looking at the hardware or equipment i.e. the computer itself but at the software or as we prefer to call it courseware.

It is courses that are approved for tax concessions not equipment or software that operates the equipment.

In other words, we cannot register or apply for approval for training purely on the basis of a computer based system of training, just as we cannot apply for approval of the overhead projector (hardware) and transparencies (software), or if you like T.V. and Video films. It is the courseware that is all important.

2. BASIC COURSEWARE DESIGN MODEL

The model is divided into 4 broad areas, each corresponding to criteria of the Department of Manpower requirements for training course compilation.



1. Need Analysis
2. Training Analysis
3. Synthesis & Validation Design
4. Implementation

I will briefly deal with each section and make specific references to the Cybercom System which is presently being used by a large S.A. Company.

To start, it is necessary to draw a distinction between educational teaching systems and teaching systems intended for a training context. In a functional training system :

- Everyone is expected to succeed
- Those who have difficulty are given further coaching until they do succeed.
- Those who learn easily reach the standard sooner or with less help from the trainer
- The final standard is such that everyone can attain it (1.1)

As far as in-service training of employees is concerned, the emphasis falls on functional training.

1. NEED ANALYSIS

The decision to train usually stems from two main sources.

1. A new requirement to solve a particular problem.
2. A problem which is a direct result of performance discrepancy which may be rectified by training or re-training.

Regardless of the source - Analysis is necessary as the decision to train must be based on a real need. We cannot afford to

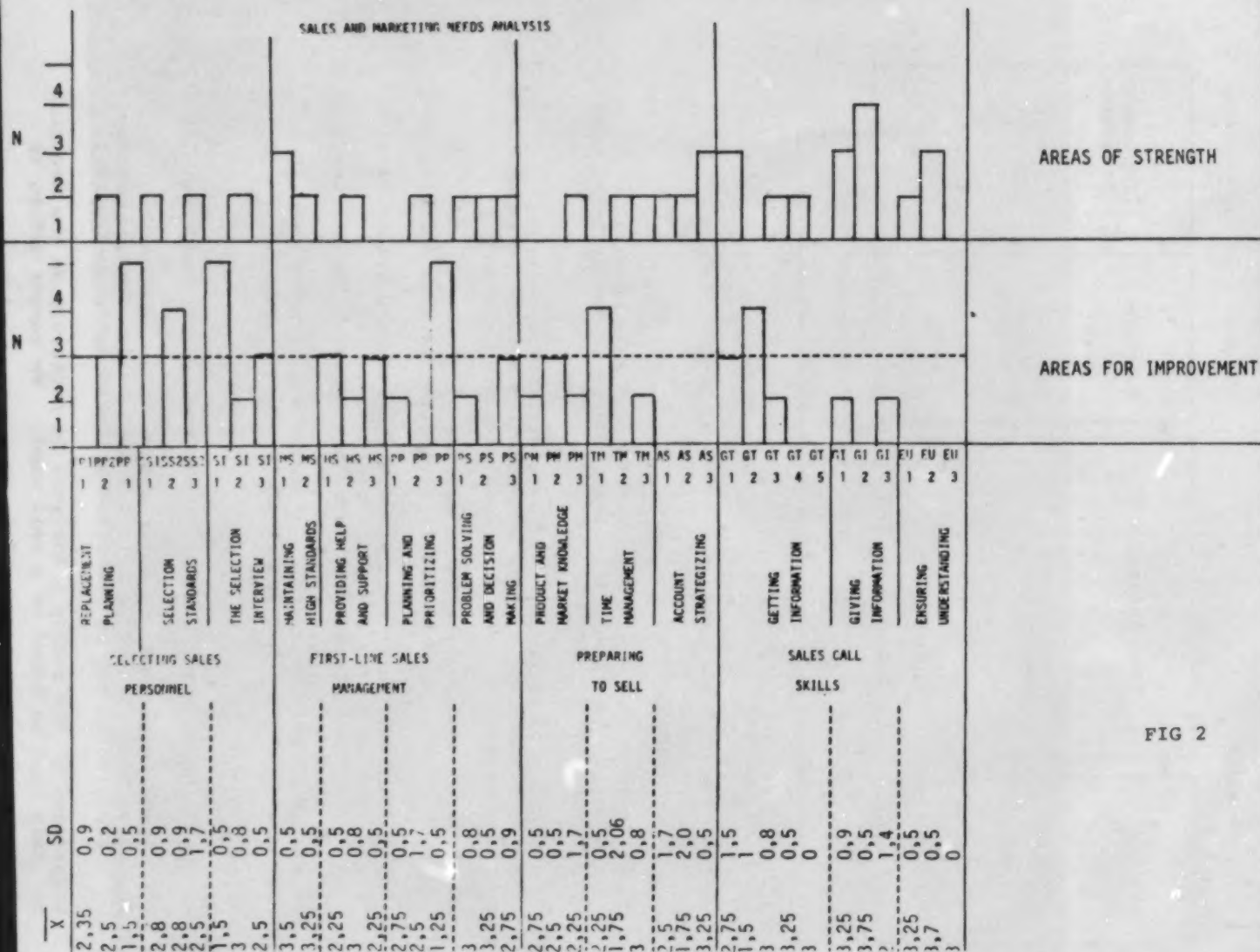


FIG 2

train for the sake of training. Courses submitted for approval have to be based on a clearly identified need in the organisation.

It is interesting to note that the computer can assist in this process and that Cybercom can and has been used in this role by management and trainers.

An example of a marketing need and sales training analysis is shown in Fig.2

2. TRAINING ANALYSIS

This step involves three subsystems.

- 2.1 Task Analysis
- 2.2 Statement of training tasks and behavioural objectives
- 2.3 Structure analysis

It is the view of the Department of Manpower that before training of any employee can commence, a proper analysis must be made of the job he must do. The results of such a job analysis will determine and indicate its main component tasks. Each task will consist of a number of identifiable activities which should be classified in a chronological sequence. To perform each activity the related knowledge and skill with possible key factors (such as safety, tolerances performance standards) should be determined.

It is generally accepted that the same job in two different environments can differ to a large extent. This places a critical disadvantage on systems which use packaged courseware. Either because it is not all applicable or that it is too expensive or time consuming to alter.

Cybercom was specifically selected for this feature as it is an essential component of industrial training. The instructor can make any change on the spot to suit his presentation. Also in terms of updating courseware as processes and procedures change much more rapidly than educational concepts.

3. SYNTHESIS

With the instructional objectives clearly in mind, the course developer is ready to plan a programme of instruction. This synthesis consists of 4 subsystems

- 3.1 Developing a scheme of work
- 3.2 Determination of Instructional Methods
- 3.3 Drafting of Courseware
- 3.4 Validation Design

3.1 The scheme of work is a valuable document as it is designed to fulfil a number of roles, viz. Firstly it is the document that has to be submitted to the Department of Manpower. It forms a standardised approach to the presentation of training material

which makes for easier evaluation by the Department.

It provides a control document whereby management can assess the relevance or effectiveness of the training being offered to their employees.

It forms a basis on which lesson plans (or instructional plans or training manual) may be drawn up by a suitably trained instructor.

It provides a quality control mechanism for controlling the consistent application of the training course content by various training officers and/or establishments.

3.2 Training Technology recognises that there are many different training strategies and methodologies for teaching and learning. Choosing an appropriate strategy will depend broadly speaking, on three main criteria.

1. The nature of the learning objectives to be realised.
2. The need to enrich the learning experience so as to harness intrinsic as well as extrinsic motivation.
3. The ability of the students involved in the task.

(2.1)

There are times when the trainer could do the job more efficiently, by lecturing himself than by the students working independently.

As Peter Drucker pointed out "Throughout the ages the problem has always been how to get communication out of information."

In industrial and commercial training this is a critical area as the use of multi-media has generally been used by trainers in the past. It was therefore necessary to ensure that all modes of teaching and learning could be achieved by a computer system and that these could still be integrated with the familiar audio visual aids that have been used to date by trainers.

3.3 Drafting Courseware.

This is the work done to lay out the course package. It includes all the material, instructions, resources and questions for the trainer and student. Whether the course is in a social teaching mode or self-paced mode the courseware will be designed to achieve the instructional objectives. The instructor himself may and should be involved with this aspect.

Cybercom allows this, as courseware design can be done in plain English or Afrikaans or any other language with no knowledge of conventional computer programming.

3.4 Validation Design.

Internal Validation, determines at the end of the course, whether

the trainee is able to meet the objectives for which the course was designed. The focus of internal validation is on content and procedure of instruction and on criterion testing. When the course developer prepared the curriculum by writing the behavioural objectives during the analysis phase of the system, he also outlines the criterion referenced tests which will measure student performance of those objectives. Thus there are several benefits:

- 1) C.R. tests follow naturally from well designed objectives.
- 2) Validation of test items and of instruction follows in a clear and straight forward way.

Constructing the internal validation design thus requires procedures to validate the course and to make changes where the test data may indicate them to be invalid.

There are two implications here for the industrial trainer.

1. In order to obtain Departmental approval for schemes of work a completed test specification for each task must be included.
2. A systems approach to instruction is a closed loop, self correcting process which moves from identified needs to predicted outcomes (Kaufman 1972). Validation procedures provide the feedback for self correction when necessary thus keeping the system operating effectively. Validation procedures are planned during the synthesis phase so that they can be put into immediate use during the implemented phase.

The Cybercom system employs continual measurement of student performance and courseware validity which allows the self correcting process to operate.

4. IMPLEMENTATION

The implementation of the training has to be scheduled. This covers items such as sessions involved, timing, venue, type of instruction.

Again whatever methodology is used when the course is initially implemented, external validity is assumed. Therefore during the initial implementation the focus is on internal validity.

These are :

1. Do the test items accurately reflect the instructional objectives ? and
2. Does the training programme fully prepare trainees to pass or achieve the test items based on those objectives.

Collection of Validation Data.

The goal of instruction (Criterion Referenced Instruction) is for

all students to succeed in 100% of the test items. Therefore course managers are concerned primarily with those items which students fail. The failures must be for one of four reasons :

1. The test item is faulty.
2. Instruction in the area tested is inadequate
3. Students entry-level competencies were inadequate or incorrectly measured.
4. Students made errors for such reasons as lack of effort, carelessness or inattention.

Immediate feedback to trainers and students in this regard is essential. A computer system like Cybercom that provides this statistical information is invaluable in the modifying of courseware. Trainers and course managers can analyse results in terms of student performance and their own performance.

Feedback loops such as this in the system provide the necessary modification to either the specific training objective or to modify the courseware so that the system can be validated for a specific training objective.

CONCLUSION

A systems approach of this nature, meets the criteria for effective training in industry as well as allowing a company to register their schemes of training for the 200% tax concession.

A computer system, which can be used in

- (1) Needs Analysis
- (2) Courseware development pertinent to those Needs
- (3) Any teaching strategy or methodology
- (4) Provides Validation data

and allows immediate modification of courseware, meets the requirements for industrial and commercial training.

Such a system is presently being used by a South African company and a case study of this will now be presented.

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THE USE OF A CYBERCOM SYSTEM IN AN INDUSTRIAL
SETTING - A 3M CASE STUDY

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ABSTRACT

Industrial establishments usually have a variety of training needs which can be met through the use of different teaching strategies. For example the teaching of product knowledge or basic language skills such as spelling and vocabulary can best be accomplished through a self-paced mode of learning, whereas behavioural subjects such as management training are best taught in group situations.

An outline of the Cybercom System at 3M is given. Next, our experience using the 16 terminal system, in both group and individual work using a wide range of company courses on a range of employees is reported.

The use of the system in Conference Management and group-decision making is mentioned.

INTRODUCTION

In the South African context, training in Industry and Commerce presents challenges and opportunities rarely found in countries whose peoples share broadly similar cultural orientations. Whereas the aim of training in Industry and Commerce is (1) concerned with the acquisition and development of knowledge, skills, techniques, attitudes and experiences which enable individuals to make their most effective contribution to the efforts of the team in the short term, the objective of training could equally be long term in the sense of preparing those individuals for greater responsibilities in the future.

The latter long-term objective we will call individual development, which depends for its success on sound and focussed short-term training. However, the results which can be achieved by training in industry and commerce will be limited by the quality of the basic education which the trainees have received. Whereas the distinction between the concepts of education, training and development may, under normal circumstances be of academic interest only, the problem facing industry and commerce in South Africa is one of clearly understanding the role of each process in the orderly progress of the society. A solution has to be found to the problem of attempting to provide industrial training as a panacea for shortcomings in broad education and individual development. In the majority of cases training in industry and commerce supplements basic education, and individual development is, at best, left to chance.

Education, training and development thus become vehicles for the transmission of values in industry and commerce. The importance of this viewpoint cannot be emphasised sufficiently in the South African context with its multiracial inputs into the work environment. A system of teaching and learning is therefore needed, which while striving for the same optimum learning objective, is, nevertheless, flexible enough to accommodate different approaches to teaching and learning.

THE AIMS OF EDUCATION AND TRAINING AT 3M

The principal objective of our Education and Training is to bridge the gap between cognitive theoretical learning acquired through formal institutions of learning and the practical application of that knowledge in actual job situations. As a secondary channel of training within the organization, we attempt to approximate, as realistically as possible, the relationship that must exist between subordinate and supervisor in the primary channel of training. The imperative is, therefore, to re-create an attitudinal climate to facilitate learning through the primary process. In addition to inculcating correct attitudes for learning, the other objective is to transmit knowledge in, and related to, the field of work done by the trainees. Programmes ranging from Plant Orientation (adjustment to shop floor routine and practice) to Management training have been developed and are offered. For this purpose we need to manage the learning-teaching situation in such a manner that the five criteria for effectiveness in a job will be met and enhanced where possible. The criteria are:

- Knowledge
- Skill
- Technique
- Attitude
- Experience

No one can really claim to know how learning occurs, but we do know that learning (2) is a process which takes place within the individual. The function, of the trainer, then, is to entice this mysterious process by utilizing the trainee's experience bank as bricks and mortar for further learning. On the other hand, the apathy in industry and commerce towards training is certainly not without justification. Much of the apathy is due to poor instruction, ill-trained instructors, training not adequately geared to job requirements, poorly designed programmes, meagre or non-existent incentives to learn. No one can blame managers for being apathetic. To overcome some of these common problems, we need a teaching-learning strategy which is managed for the optimum benefit of the learner.

IN QUEST OF A TEACHING-LEARNING STRATEGY

Theories of learning are well documented (3) and the resultant principles of learning are identified as: Motivation to learn; reinforcement of the appropriate response; immediate feed-back of results; applicability of learned material and involvement and practice. We may add the sixth, and fairly important principle here, that of perception; for, without the operation of this principle, understanding will be difficult to evaluate. Consequently, the management of a teaching-learning situation must take into account these principles and base its strategy on assumptions flowing from them. These assumptions are listed as follows:

- People do not learn equally well by the same process.
- To facilitate learning, knowledge must be perceived to be applicable to situations known by the learner.
- Motivation to learn is impacted by the relevance of the learning.
- Learning is impacted by involvement.
- Success experiences during learning are motivation for the continuation of learning.

Methods and techniques of teaching to meet some or most of the principles of learning are abundant, but what seemed to be lacking was a strategy which integrated the various processes of training into a flexible system at the command of the trainer. The trainer must (3) guide the learner and reinforce current responses, he must provide the learner with an opportunity to associate, he must provide him with an opportunity to discover for himself, and he must give him an opportunity to practice and to apply his knowledge. New technology in the field of computers in education seems to open new possibilities for multi-process teaching strategies.

THE USE OF THE CYBERCOM SYSTEM AT 3M

We stated that education, training and development in industry and commerce is a process of transmitting values. A two-way communication is an essential ingredient in such a process. The Cybercom (Cybernetic Communication) System provides a channel for this two-way communication. A live communicator, therefore, forms part of the system. The computer capabilities do not replace him, but they enhance his/her communication abilities and help him to manage the process better. Generally speaking, transmitters and carriers of values in a society or group are live agents.

The 16 terminal system at 3M is not only used for general educational subjects such as English, Mathematics and other school subjects, but also, and primarily, for a wide range of industrial courses. These range in complexity from the simple cognitive learning of single words or phrases relying upon memory and retention, e.g. spelling, vocabulary, product characteristics, to the more complex interactive behavioural courses such as Selling Skills and Management Training.

DESIGN OF CENTRE

Seating in the Cybercom classroom is arranged in theatre rows to facilitate eye contact between teacher and pupils.

The more commonly used audio/visual media are positioned in such a manner that they are visible and audible to everyone in the class. The advantages and limitations of media (3) notwithstanding, we have arranged them in a sequence to overcome some of the commonly held stereotypes about the perceptual skills of certain cultural groups. For example from right to left (at trainer's position), the overhead projector provides a single dimension. Next the rear-view slide projector adds another dimension including depth. The television screen adds other dimensions of motion and sound. All these media are centrally controlled at the trainers V.D.U. and can be accessed appropriately as required.

USE OF THE SYSTEM

Our apprehension about the use of the new technology with the predominantly unskilled shopfloor workers proved to be groundless as the majority of the class proved capable of adapting to the system after a brief familiarization period lasting no more than 10 - 15 minutes. We were then able to teach such complex subjects as Personal Health Care and Plant Orientation. This was made possible by the flexibility of the system. Two strategies for teaching of courses are available. In teaching courses such as those mentioned here, where we rely heavily upon the experience bank of the individual participants, we chose the option of teaching through the social mode, mixing both group teaching (lecture) and discussion (interactive).

A management training course and a bookkeeping course have been delivered through the system. In both cases the trainers were encouraged by the performance shown by the students.

The self-paced mode of learning has been applied on those programmes which have, in the short space of time since installation, been amenable to programming. Mainly product knowledge type evaluation programmes such as Chemistry and Film Examination and Engineering and Technical Aptitude have been used in this mode up to now.

ANALYSIS OF RESULTS - TENTATIVE OBSERVATIONS

Evaluation of application is primarily at the reaction and the learning levels. Results of the post training scores show promise. No comparisons with results from using any other system, including conventional teaching methods, are possible at this stage. The system is hardly more than two months in use.

However, observations at the teacher-student reaction level are certainly not out of place here:-

- The synthesis of the various strategies, training processes and media into a single system gives Cybercom a high face validity for industrial and commercial training.
- Teacher presentation of the learning material is guided and kept consistent and probably improved through a process of criterion referencing when programming preferred responses.
- Most of the principles of learning are met: reinforcement and feedback are immediate; application of knowledge is determined by course design; participation and practice are achieved through obligatory student responses.
- Economy on teaching time is achieved through managing by exception.

The system has been used in small Conference Management and consensus decision making situations. The atmosphere created in such situations is non-threatening and is confidence-building because of the knowledge that opinions and ideas are anonymous, therefore secret, and independent. By means of simple rating scales, consensus is quickly reached and commitment to action assured because it is the view of the majority, and is not influenced by status considerations.

BEYOND INDUSTRIAL TRAINING

In an effort to discharge its social responsibility and earn its citizenship in the community, 3M has undertaken a project to up-grade the teaching skills of mathematics of the entire primary school teacher population in one township. We expect Cybercom to achieve this objective. Its flexibility, its multi-media and its multi-process capabilities make it uniquely suitable to do so. We also expect that its role in improving the communications skills of even the retarded pupils will prove its worth, since retardation in many instances is aggravated by the lack of opportunity to form and practice words and phrases.

The potential for mass communication in education and training is now possible with the new computer technologies. The computer has now come of age to be able to enhance the role of the teacher in the transmission of cultural values within his society. It should enable him to communicate with, and simultaneously listen to, many people at once.

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COMPUTER-ASSISTED LEARNING IN THE PRIMARY SCHOOL: NOW AND IN THE NEAR
FUTURE

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ABSTRACT

C.A.L. Suits the Primary School and vice versa. The learning material is relatively simple, and often repetitive. The learner is unsophisticated, does not fear new technology and is fascinated by the computer. The computer is well suited for the interactive, sequential learning tasks which form a large part of today's primary school work.

Current use of C.A.L. in Primary Schools is not as widespread as we might expect. There is enthusiasm in the United Kingdom and Australia, but few routine applications. C.A.L. seems to be more accepted in the U.S.A., especially in Alaska.

C.A.L. is not likely to spread fast in primary schools while there is an abundance of reasonably qualified teachers. C.A.L. in the Primary School often has a low official priority and is left to the teachers' initiative. Few primary school teachers are interested in computers. There is considerable resistance to technical innovation and there are few competent programmers among the ranks of primary school teachers.

There is a future for computers in Primary Schools in South Africa. When used for administration analysis and management, the computer can justify itself. C.A.L. is becoming very attractive for the areas where teachers are either very expensive or not available: remedial teaching and teaching the intellectually gifted. The computer can cater for some of the needs of the remedial pupil and the gifted pupil.

C.A.L. projects currently underway in South African Primary Schools.

THE CO-ORDINATION OF COMPUTER-BASED EDUCATION ON A REGIONAL LEVEL

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ABSTRACT

This paper presents an analysis of the problems involved in the introduction of computer-based education in schools and considers how these problems are being countered in the Cape Province. Problems discussed include hardware selection; software development and maintenance; lack of skilled manpower at the decision making level and at the grass roots level; and professional jealousy. Solutions proposed include: the setting up of programming teams to develop software; the provision of guidelines for a sound purchasing policy to make optimum use of resources; and the establishment of a body to co-ordinate the use of computers in schools.

INTRODUCTION AND DEFINITION OF TERMS

In the history of modern education, it would be hard to find a greater waste of effort and money than that which has occurred in the field of computer based education. Most of the wasted effort has occurred in countries of advanced technology; and by observing their mistakes, South Africa may be able to avoid making similar ones. This paper attempts to analyse the problems involved and to suggest some possible solutions.

Definition of Terms

The term "computer based education" is used in this paper to include any educational situation in which the computer plays an active role - whether this is as apparatus in computer studies; as subject of study, problem-solving tool, or situation-simulator in computer literacy; or acting as teacher, monitor or apparatus in some or other form of computer assisted learning.

A region is hard to define, but for the purpose of this study it may be taken as any area which could effectively be placed under one education authority.

The problems associated with computer based education fall into two broad and overlapping categories: Financial and Humanitarian.

In a time of financial recession, with education budgets trimmed so severely that they scarcely meet conventional demands, it requires courage to commit a large amount, by educational standards, of capital to equipment which advancing technology may render obsolete by the time it is introduced.

With computer experts advising the writing off of equipment over three years (1), a conservative education authority is gratefully inclined to adopt a wait and see policy, perhaps not realising that the pace of change is accelerating and that procrastination now, will merely increase the cost of introducing computers at a later stage. This writing-off period of three years is calculated on the equipment becoming obsolete rather than unserviceable. It would be more realistic to plan for the working-life of a machine. The working-life is usually inversely proportional to the number of moving parts. As these are restricted to a minimum in most micro-processors, we can expect a working-life of from 5 to 10 years. To make full use of the machine lifespan a sound purchasing policy with regular expenditure on an annual basis is required.

To make optimum use of resources, a sound purchasing policy will divide computer based education into its many facets, and to each facet assign a priority. The current budget and any existing equipment will then be allocated to each facet according to its priority. For example, an education authority may divide computer based education into the categories given in table 1, with the accompanying initial priority ratings.

TABLE 1

Category	Priority rating Scale 0 - 100
Computer Studies for senior pupils	50
Remedial Computer Aided Education (Age 15 - 18)	10
(Age 12 - 15)	5
(Age 8 - 12)	5
Computer Aided Education for gifted child	
(Age 15 - 18)	5
(Age 12 - 15)	5
(Age 8 - 12)	0
Computer Aided Education for the average pupil	
(Age 15 - 18)	0
(Age 12 - 15)	0
(Age 8 - 12)	0
Computer Literacy (Teachers)	20
(Pupils)	
(Age 15 - 18)	0
(Age 12 - 15)	0
(Age 8 - 12)	0

With these priorities, the bulk of the budget will be spent on equipment for computer studies with the choice of equipment highly dependent on its suitability for some form of remedial computer aided education, and its suitability for future use in categories with a currently low priority such as computer literacy. There are so many different equipment features and designs that it should in most instances be possible to dovetail requirements in this way.

If this is not possible, it may occur that two groups with high priority ratings will demand mutually exclusive equipment: then the budget will have to be divided between the two groups. Individual education departments would determine their own priority ratings and these would be revised with changing circumstances. By reallocating existing equipment at every stage, no equipment should become obsolete before it is unserviceable.

Taking our hypothetical department as an example. In year 1, given the priorities of table 1, it purchases 100 popular micro-computers, which are to be placed 5 to a school in 18 schools where they are to be used for the teaching of computer studies and for remedial education of pupils aged 12 to 18 years. The remaining 10 machines are divided between a software development centre, where a team of teachers and computer programmers are developing software, and the teacher training facilities where they are being used for computer literacy. In year 4, an efficient and inexpensive network system - the ideal thing for computer aided education - establishes itself on the market. The micro's, now 3 years old but still good for another 4 years or so, can be reallocated almost entirely to computer studies or to computer literacy classes and the annual budget concentrated on computer aided education and maintenance of existing facilities.

The exorbitant cost of maintenance policies, usually in the region of 10% of purchase price p.a. implies that any purchasers of equipment on a large scale must be prepared to set up their own maintenance department. Ease of maintenance and mean failure time must therefore be key factors in the choice of hardware. The problem of providing maintenance in isolated or distant parts of the region has also to be considered.

The cost of both hardware and maintenance can be reduced by the standardisation of equipment. Collective buying can reduce the purchase price, and standardisation obviously reduces maintenance costs. Interfaces to slide projectors, tape players and video recorders can be made available with standardisation. This obviously requires standardisation of more than just computers.

The initial choice of hardware poses a problem. Published comparisons of micro-computers tend to represent only superficial characteristics and those that can be easily measured in a casual review. To overcome this problem, the Cape Education Department tested a number of different machines, on site, over a period of six months. The resulting evaluation of the machines is extremely useful, not only to the Department, but to any education department in a similar position. Pooling of experience and unbiased equipment evaluation is a very necessary part of development.

A major criterion in the choice of hardware is the existence of suitable software to accompany it, and in any event the ease with which further software can be developed. In the long term, software is likely to be the most costly requirement. One of the main problems associated with this cost is its estimation. The tendency observed among schools which acquire a computer system designed to do A,B and C is to desire it, as soon as it is working, to do X,Y and Z as well. This "creeping feature creature" (1) causes development cost estimation to be extremely difficult. Coupled to this is the normal maintenance cost of computer software, generally held to be in the region of 50% of the total cost of software. The initial estimation of software development cost is a major headache throughout the computer industry.

The larger the market the smaller the software development cost. Different sociological conditions, in different regions and even in the same region, limit the applicability of educational software. For example South African educationalists find most American educational software totally unsuited to our education-system. The difference in cultural background between white and black limits the transferability of software even further. If software interchange is limited still further by incompatibility of hardware devices the cost of its development will prove prohibitive. Standardisation of equipment to ensure compatibility is therefore important. However, machines do not last for ever, and it is therefore necessary to adopt the principles of modularity in software development. The software system developed at the Chelsea College in London (2) is a worthy example to follow. Chelsea College has developed a library of standard subroutines for performing routine computer aided education tasks. By adopting such a system, the cost of adapting existing programs to machines of the future will hopefully be minimised. Such a system requires professional programmers.

Software to be technically efficient must be developed by programmers. Software to be pedagogically sound, should be developed by educators. The combination of both skills in one individual is rare, and having regard to the full range of subjects available at high school level it is unlikely that someone versed in enough of these will be willing to undertake such a task. Software tends also to be out of touch with the preferences of the teachers, as programmers are inclined to program something which appeals to them as a good topic, whereas if the teachers had their way the programs would tackle the more mundane aspects of the syllabus such as drill and practice. There is danger in allowing the development of educationally unsound software.

Poor software will discourage some educators from using computers at all. To overcome this difficulty, manufacturers and others, have attempted to produce author languages such as "pilot" to enable teachers to program lessons. As yet there does not appear to be a sufficiently powerful author language which is suitable for use on bottom-of-the-range equipment.

The alternative is a software development team consisting of a programmer and a group of teachers. This would supply software which takes advantage of the capabilities of the computer and which is tailored to local needs e.g. syllabus requirements, and local taste. By alternating the teacher group, software would not be stereo-typed, but would represent various educational philosophies and personal preferences. Continual evaluation of this software is important. The continuity established by having one programming team would increase the possibility of standardisation of programs and their development in a modular fashion and also make pupil interface features (such as entering information) consistent within a program series.

The alternating of the groups of teachers will not only increase the number of teachers with an understanding of computers, but will spread computer awareness and interest in a system renowned for its resistance to change.

Many foreign programs which at first appear unsuitable can be adapted to suit local conditions by such groups.

Apart from these programming teams a foundation, similar to the Foundation for the Advancement of Computer-aided Education (3), should be established to award grants to assist educators in the development of innovative educational software. This foundation would be financed jointly by the private sector and the state.

The lack of suitable manpower is a greater hindrance to the development of computer based education than either the over-abundance of rapidly developing hardware or the lack of suitable software. In a profession whose tradition demands that its commanders come up through the ranks, it is not surprising that there is a lack of computer expertise at the decision making level in a field which is less than 20 years old.

Resistance to change and reluctance to make what are far reaching decisions is understandable under the circumstances. However, the question "should we use?" has been clearly answered worldwide and the question of how best to make use of computer resources has now to be faced. This is more than just a question of obtaining suitable equipment or designing a syllabus suitable for computer studies.

"Programming, the Second Literacy" (5) demands a completely new approach to the design of syllabi across the entire educational spectrum - a change as radical as that caused by the invention of the printing press. The introduction of computer based education allows a swing to the "doing and exploring" type of education advocated of old by Piaget and Montessori and more recently by Seymour Papert (4).

Let us trust that our leaders, who have the responsibility of deciding the speed and direction of education's entrance into the computer age, may guide with foresight and wisdom into this momentous and unfolding era.

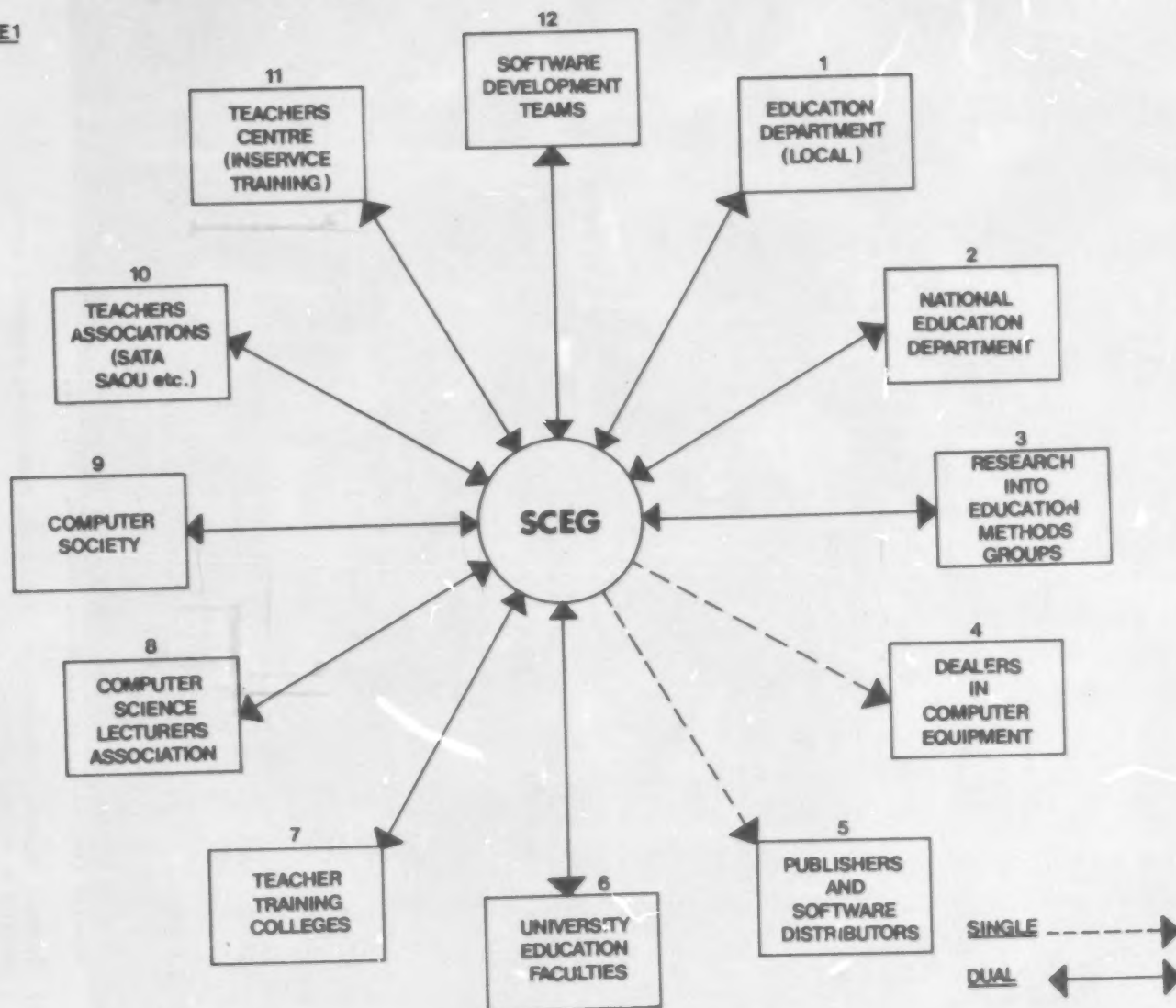
Meanwhile the tasks of obtaining suitable equipment, developing the necessary software and designing computer studies syllabi, have to be performed. There can be no excuse for the purchase of deficient systems. To assist the Administrator in this difficult task, is it not essential to appoint as his advisors, a team of consultants? This would make available to him the necessary expertise.

The general solution to the problems occurring in computer based education is the formation of a co-ordinating body. Following the successful examples provided by bodies such as the Minnesota Educational Computer Consortium, the Schools Computers in Education Group (SCEG) was formed during 1981 to attempt to co-ordinate computer based education in South Africa, in particular in the Cape Province. SCEG is independent of, but attempts to work in close liaison with the Education Department.

A summary of the functions of SCEG is given below:

- 1) To provide objective, expert guidance in first selecting and then making effective use of a given hardware system or program, and in this way to promote compatibility of computer systems in the region.
- 2) To keep up with changing technology and market conditions and increase the quality and availability of information about computer based education.
- 3) To provide and co-ordinate the training of teachers in the field of computer literacy, whether this be inservice training or ab initio training at teachers' training colleges or university education faculties.
- 4) To provide people seeking to use advanced technology in education with "hands on" demonstrations of equipment. This requires local expertise and needs decent software which will not go off half-cocked.
- 5) To co-ordinate and encourage the development of software by setting standards for good educational software, polling teachers to determine their software preferences, adapting existing software to meet local conditions, and assisting in the location and evaluation of existing software.
- 6) To encourage and facilitate review of hardware, software and applications by experts and experienced users within each discipline.
- 7) To assist in the design of syllabi in Computer Studies and related disciplines.

FIGURE 1



- 8) To co-ordinate research and development in computer based education.
- 9) To supply teachers interested in developing their own computer-aided education programs with a library of standard sub-routines for performing routine computer aided education tasks and thus avoid as it were the reinvention of the wheel at each centre.

The relationships of SCEG to existing organisations is illustrated in figure 1. In most cases the relationship is obvious or has been elaborated above. Notice that some of the links are only in one direction, indicating that the party has no say in the policy of the co-ordinating group. It was felt for example that dealers should be restricted to allow the groups decisions to be made objectively.

A major problem inhibiting co-ordination is professional jealousy. This has caused a number of separate co-ordinating bodies to be set up, and has restricted the flow of ideas and information within the body. One of SCEG's objectives is to amalgamate with any body that has similar aims even if this means a loss of identity. There seems to be a measure of reluctance on the part of the various education departments to formulate a common policy. Prince Machiavelli himself would be hard pressed to overcome these difficulties. No immediate solution presents itself.

Many of the problems particular to schools are also being experienced throughout our society. Certainly there is a lack of computer expertise and a lack of basic knowledge about computers, which some would refer to as computer literacy. This can be tackled on a national scale by encouraging the local television authority to embark on a national computer literacy programme similar to the BBC's highly successful programme; "The Silicon Factor" and the new ten part series "Hands on Micro's".

The many problems facing the advancement of computer based education can only be overcome by a concerted and co-ordinated effort to make optimum use of the available manpower and financial resources. It is hoped that the ideas put forward in this article will be useful in this regard.

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ON DEMYSTIFYING THE COMPUTER

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ABSTRACT

Amid the broad superficial coverage of many computer literacy curricula, and the confusing unnecessary technical detail of others, an important goal can be overlooked. This is the development of a sense of what computers really are and do, and of how they work. This is a desirable and realistic goal, if tackled on an appropriate level, appealing to intuition rather than rigorous demonstration, with frequent illustration by analogies drawn from everyday life. The subject is analysed into four fundamental areas - symbolic representation, manipulation, algorithm and structure, and suggested strategies are given for teaching about them at school level.

Introduction

The curricula of the currently proliferating 'Computer Literacy' and 'Computer Appreciation' courses show remarkably little consensus as to style and content. They tend to range from what are essentially introductory programming courses to wide-ranging surveys of computer applications and 'computers in society', while some attempt in addition a superficial global coverage of Boolean Algebra, digital electronics, computer architecture, machine-code programming and algorithmic design. What however seems to be lacking in most cases is any serious and realistic attempt to provide a viable conceptual model for the learner to appropriate and internalise to enable him or her to think about what a computer is and does in a confident and fruitful way. I believe, on the basis of careful but informal observations made during series of introductory lectures on the computer given to university extension classes, students and schoolchildren, that a clear exposition of the computer on that level is an urgent and widespread need, to dispel the aura of mystery that surrounds computers and the sense of alienation that many people experience in relation to them, and to permit a proper and appropriately critical appreciation of an ever more dominant element in our lives and culture. In the context of school, it seems particularly important that, if computers are indeed to come to play an important role in day-to-day school experience, pupils should have a sound insight into their nature and appreciation of their potential and limitations.

One could in principle formulate a wide range of objectives, in both the cognitive and affective domains for a course in computer literacy to meet this need. However, in the present pre-paradigmatic stage of development of the subject, it seems premature to attempt to do so, and the outcome of other large-scale studies of this kind (1) suggest that in these circumstances an attempt to ensure rigour and verifiability in curriculum design may result merely in its trivialisation. It is possible however to state some broad aims:

- To dispel the myth that computers are mysterious and inscrutable devices whose inner workings cannot be usefully and convincingly explained to ordinary people.
- To show where the computer fits, historically and logically, in the universe of human artifacts; and in what ways it resembles and differs from other machines.
- To explain the mechanisms and processes of the computer by analogy with simpler, more transparent or more familiar objects and processes drawn from the everyday world of the learner.
- To show how information can be symbolically represented in a machine, in the form of 'bit-patterns'.
- To show, again by simple analogy, that meaningful tasks can be accomplished by means of mechanical manipulations carried out on these symbols.
- To demonstrate that significant tasks can be decomposed into sequences of simpler operations.
- To convey a sense of the way in which complexity can be built up by the repetition and modular structuring of simple elements, and
- To account for the power and versatility of the computer, and impart a sense of the kind of task to which it can (and cannot) be applied.

Lest it be thought that to aim at real understanding of this kind at school level is utopian, it must be emphasised that the rather abstract way in which the above aims are formulated in no way reflects the proposed style of treatment in the classroom. It is central to my proposal that the treatment be simple and concrete, free from jargon and technicalities and firmly grounded, through the extensive use of analogy, in the ordinary, everyday world of the child's experience.

On this basis, I will sketch in outline a proposal for an integrated course covering hardware and software aspects. It will deal in an intuitive and non-rigorous way with the fundamental topics of symbolic representation and manipulation, algorithms and structure, at a level appropriate for use in schools.

Why do we need computers?

It seems both logical and pedagogically sound to deal with this question before describing their form and function, for the computer is not a natural reality but a technological artifact. It should be identified as a tool standing in a long tradition of artifacts devised by man to master his environment. It belongs especially to that subclass of tools invented (as were spoken and written language) to facilitate calculating, organising, planning, thinking and communicating. Its antecedents include writing materials, counting pebbles, the abacus, filing cabinets and adding machines, but computers share also with the steam-engine the property of quasi-autonomous behaviour, being capable of significant unattended operation for long periods. Both the steam engine and the computer are no more than instruments, but both are capable of dramatically amplifying human capacities in their respective domains.

Historically, computers were developed to meet needs for both rapid automatic calculation and mass data processing. The former is sometimes excessively emphasised in introductory courses, reinforcing the popular misconception that the computer is merely an automatic calculator. The need for data processing is more plausible to children and leads more readily to the broader conception of the computer as a general-purpose or universal symbol manipulator. Convincing examples are readily found, beginning with familiar needs like updating attendance registers and mark lists, and progressing to essentially similar file-handling tasks like inventory control. It is easily appreciated that these tasks are routine in nature (and hence mechanisable) and onerous in the absence of mechanical aid. Thus the stage is effectively set for the introduction of a machine that can provide it.

An office configured for data processing is a useful mental model of a computer. In it, a meticulous but unimaginative clerk sits at a desk. He is supplied with an array of numbered pigeon-holes for filing, an IN and OUT tray, and a pencil, notebook and calculator. His task is to process incoming messages and those already in the pigeon holes, by modifying them and refiling them according to a detailed list of instructions. It should be emphasized that the analogy is a powerful one, and that in principle (and given sufficient time!) anything that a computer can "do" (computers are instruments not agents!) can be done by our hypothetical clerk who in the process can act like an automaton and make only the most trivial kind of decisions. Exercises can usefully be set in writing sets of instructions on this level for everyday tasks.

In the computer, of course, operation is at an even lower level, the messages being individual symbols. On the other hand, storage and retrieval is vastly more rapid, taking place electrically rather than by moving pieces of paper. This need not be mysterious or confusing if it is presented in the light of the much more familiar telephone system. Here, too, remote locations are addressed by number and messages sent by wire!

A clear mental picture however requires clarification of the nature of the objects manipulated - the symbols. Discussion of the binary number system at this stage tends to confuse the learner. Representing the symbols as ordinary decimal numbers is one approach but I incline to the view to introduce the computer as a manipulator of arbitrary symbols to which various meanings can be given. The bit-pattern can be shown to be a symbol easily represented in machines, and it has little inherent numerical association for the child, though it is easy to demonstrate when required the orderly relationship between the binary code and the counting numbers.

The child should become familiar with bit patterns interpreted as numbers, names

and instructions (the example of sending messages by turning house lights on and off in patterns is a useful one) and discover by playing with them the relationship between sequence length and the number of distinguishable patterns.

Explaining how a computer works on the level of mechanism

The beginner encountering the computer is already immersed in a strange and bewildering world. What he or she desperately needs is some anchor points grounded in the world of everyday experience, not explanations in terms of the even stranger world of gates, flip-flops and Boolean algebra. The latter can be interesting and fun as enrichment material in a mathematics curriculum, but it is of little use in explaining the global operation of a computer. The systematic 'bottom-up' approach beginning with combinatorial and sequential logic and ending with computer architecture and programming seems to me quite the wrong approach for an introductory course at school level. To see so long and convoluted a path as a whole requires both a mature and self-confident mind, and a substantial exposure to the material over a long period. It is possible to follow every step of the argument and still end up feeling one has little idea of how a computer actually works. (To begin on the level of electronics, and start by introducing the transistor is even worse. The basic principles of electronics are much more difficult to teach than the rudiments of computing.)

The temptation to "begin at the beginning" and teach material which seems fundamental and (like Boolean algebra) easy and interesting must be resisted if the aim is a functional understanding of the computer. Inclusion of such detailed material not only makes it difficult to see the wood for the trees, but often leads to a sense of frustration when the initially attractive material seems to fail to lead anywhere. It often proves to be impossible to sustain so detailed a level of development and, at what seems like arbitrary points, the argument proceeds by jumps. The resulting logical gaps are painfully evident in contrast with the hitherto logical progression. This situation seems quite common in education, and often leaves the learner floundering.

It is not necessary to begin at the level of gates and flip-flops to explain, for our present purposes, how a computer works. One can begin by postulating functional modules, whose possible existence is made plausible by an appeal to analogous objects and processes within the experience of the learner, or which can be directly and concretely demonstrated. For example, the possibility of binary sorting by simple mechanical manipulations can be convincingly demonstrated by means of the classical needle-file and operations contingent on identity between two symbols can be illustrated by pointing to the existence of the combination-lock. In this way the rather abstract operations of symbol-manipulation acquire a tangible physical significance which is more important and more helpful to the learner than a probably rather mysterious exposition in terms of AND and Exclusive OR gates. A further example is the important function of Memory. Little is achieved by explaining that this is achieved by the cross-connection of two inverting gates - a concept which many university students find hard to grasp. For the purpose of a functional understanding of computers it is sufficient (and much more helpful) to point out that a memory unit consists simply of a device (like a light switch) with two distinct states and provision for remotely switching it semi-permanently from one state into the other. The significance of memory can be clarified by contrasting a doorbell push-button with a lift call-button or a service call-button in an aircraft.

Needless to say, in adopting an approach which depends heavily on analogy we are sacrificing rigour and precision, and substituting mere plausibility arguments. This is valid, however, in the context of our limited goal, which is precisely that of making the learner intellectually comfortable with the idea of computation - i.e. of making the computer plausible.

ALGORITHM: Breaking down tasks into Primitive Operations

The idea that tasks can be decomposed into atomic elements capable of direct mechanical implementation is crucial to understanding the nature of computing. The idea is best introduced in a wide variety of different contexts, including games in which one pupil programs a colleague who acts as an automaton and strictly interprets a set of primitive instructions designed by the first pupil to accomplish a specified task. Another useful approach is to require the formulation of everyday tasks such as making a bed, or procedural tasks like sorting a list into alphabetical order, in algorithmic terms. The flowchart is a clear and useful way of presenting such algorithms, although it has some limitations which are discussed in the following section.

It is important when introducing a new topic to the curriculum to consider the problem of integrating it with the existing corpus of subjects. Useful examples of the algorithmic decomposition of tasks can fruitfully be drawn from the subject matter of classical school subjects (by no means only mathematics) and the transaction need not be only one-way. As Zweerus (2) has shown, many of the activities engaged in in subjects such as mathematics, chemistry, biology and even languages - especially Latin - can be expressed algorithmically with a considerable gain in both clarity and insight into their nature. As he points out, the clear exposure of the routine nature of aspects of a subject or topic is highly desirable and serves to delineate areas in which creative input is required. An algorithmic approach serves the important role of identifying and isolating the routine parts of an activity so that they can be appropriately and efficiently handled.

While the preparatory examples mentioned above are a useful way of introducing the topic, the definitive introduction to the algorithm comes when the child has the opportunity of writing and running simple programs, and without this opportunity it seems to me that one cannot really gain an insight into the computer. The algorithmic process is probably clearest and most transparent at the level of symbolic instruction code and I believe that there is a strong case to be made for a minimal exposure to symbolic programming before encountering a higher level language. It is neither practical or desirable for the pupil to master the intricacies of a real assembly language. What I have in mind is either a paper study (or better, a computer emulation) of a very simple single-address machine featuring a highly restricted instruction-set. On this, the pupil could 'run' rudimentary 'toy' programs simply to get a feel for the way in which significant tasks can be implemented by sequences of relatively trivial operations. Operating at 'machine' level has another, psychological, advantage which should not be ignored. It offers the possibility of an identification and imaginative engagement for which Turkle (3) has appropriated the term "syntonicity". Because symbolic programming deals with real locations, the programmer can imagine the processes with which he or she is dealing in terms of the actual movement of objects from one physical location to another. This lends a concreteness to proceedings which can otherwise, for many, be uncomfortably abstract.

Most programming activity, however, will be at the level of an algorithmic language and it is worth asking whether this aspect of "syntonicity" can in any way be preserved. It appears that it can, by introducing a very restricted subset of the language (probably a good idea in any case) and providing for the learner a cardboard model of the corresponding 'virtual machine' on which to 'run' simple programs manually. (4) (It is useful in any event to emphasize that a program, as well as being a set of instructions or statements, can be seen as having machine-transforming properties. The point is rapidly grasped by children when it is pointed out that a general-purpose computer, suitably programmed, becomes a special purpose machine for playing 'Asteroids' or some other arcade-game against!). The idea of providing a physical artifact as an aid to visualising the internal functioning of a machine has been applied by various workers at other levels and for other languages (5, 6), and has been

shown to give a rapid and sound grasp of programming fundamentals to novices. A possible BASIC version is illustrated in Fig. 1. This approach is very easy to implement and could be particularly valuable when force of necessity limits the available access to a real computer.

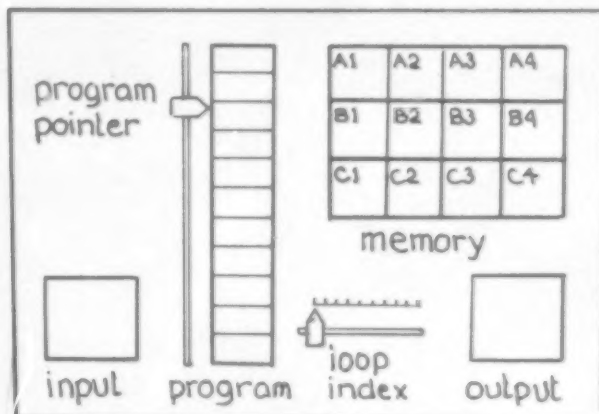


Fig. 1 A possible model of the BASIC virtual machine

STRUCTURE. How Global Complexity arises from local Simplicity

Although an understanding of the algorithm (decomposition of a task into primitive operations), and some insight into the possibility of the mechanical implementation of such primitive operations are prerequisite to any real understanding of the computer, they do not suffice. What is still lacking is an appreciation of the importance of Structure, the vital element that links local or atomic simplicity to global complexity. A mere rational demonstration (assuming a level of mental sophistication sufficient to appreciate it) of the decomposability of complex tasks into elementary operations realisable by simple hardware is not sufficient to make it credible that structures of the enormous complexity required can actually be created. Confronted by the complex and subtle behaviour of a computer executing a large program, the learner is likely to remain intellectually uncomfortable and mystified.

At the level of symbolic programming, the rudiments of significant structuring are easily introduced through the concept of macro instructions, which may be introduced as the simple clustering of primitives, for convenience and economy of effort. There is little difficulty in appreciating that macro instructions permit, in effect, an arbitrary extension of the available repertoire of primitives. It is also easy to see that if macros are used extensively, the complexity of the resulting program can grow rapidly for a modest input of programming effort. If time allows, it is probably worth developing in detail a manifestly useful extension of a restricted set of primitives - say integer multiplication using addition and conditional branching.

At the higher level of the algorithmic language, a similar role is played by the subroutine or procedure. The concept of programming in a modular fashion by the definition of autonomous procedures which are subsequently used as super-instructions' lies at the very heart of contemporary computer science, and it is a major criticism of a language such as BASIC that it does not encourage this way of thinking about programming. Indeed, it can be quite difficult to convince people whose only experience of the computer has been the writing of simple 'toy' programs in BASIC, of the power and centrality of the subroutine. It often appears to be no more than a convenience for avoiding the repetition of source statements when part of a program has to be executed many times, and this situation tends not to occur all that often in the

kinds of programming the beginner is likely to encounter. Some have even suggested, quite mistakenly in my view, that the subroutine could be omitted or de-emphasised in teaching about programming at school level.

Some feel more strongly than I do about the unsuitability of BASIC as a teaching language, on account of its lack of structure, and suggest that a language such as Pascal be used from the start. In some countries, educational authorities have acted decisively in the matter. In Denmark, for example, (7) a special language, COMAL (Common Algorithmic Language) has been commissioned and widely introduced in schools. State funds for the purchase of computers were only made available if the computer supported COMAL, a fact which guaranteed the rapid availability of computers with COMAL interpreters! COMAL is reputed to be no harder for the beginner to learn than BASIC, but it features modern structured control constructs (such as REPEAT...UNTIL, WHILE (condition) DO etc.) as well as peripheral advantages such as multiliteral variable names and a print option ("prettyprinting") which causes the source statement listing to be indented in a way that reflects the program's logical structure. Desirable though these features may be, I doubt whether they are crucial. If we are stuck with BASIC I do not think it matters too much, as long as we do not permit the deficiencies of the language to determine how we teach programming.

For many complex tasks in the real world the decomposition into self-contained sub-tasks is a natural and readily comprehensible one (even for as simple a task as making a cup of tea, the sub-task of boiling the kettle can be identified.) Similarly, computational tasks such as updating a file or sorting a list readily can be seen to yield to this kind of partitioning, but this is easily lost sight of if too early a start is made on coding in a language like BASIC. The answer is to identify the structural elements of the required solution and identify them clearly on paper before any code is produced, in a manner related to 'top-down' programming (but less rigorous, remembering that our aim here is not the vocational training of future programmers, but the general education of children into the essence of computing.) The flow-chart, though it represents simple algorithms well, is not ideal for elucidating inner structure, since it focuses attention too exclusively on flow of control. Better for the purpose is a kind of 'structured English' akin to (but less terse and formal than) the pseudocode that is now almost universal in computer science. Extensive practice in the rendering of the solution to both everyday and computational problems in this form could pay dividends in insight into the way in which complexity is mastered.

Finally on the topic of structure, mention should be made of the "conceptual building block" approach to introducing the computer introduced by Seymour Papert at MIT, and for which Papert was recently awarded the Marconi International Fellowship. It is not possible to do justice here to the rich and rather radical theoretical background to Papert's work (he is a professor of both Computer Science and Education and studied under Jean Piaget, by whom he was deeply influenced.) For this the reader is referred to his book 'Mindstorms' (8). Papert has pioneered the use of a powerful and sophisticated language 'Logo' which is nevertheless extremely simple for children to learn and use. 'Turtle-talk' is a subset of Logo. This is a language which enables a child to control the movements of a mechanical 'turtle' or of a surrogate turtle in the form of a blip of light in a video screen. Elaborate and exciting graphical designs may be drawn using procedures built up by the child out of an extremely limited set of primitive instructions, and parameters may be passed to the procedures and modified in loops to produce striking animations. The system has been used experimentally in many educational contexts and may well be one of the most important contributions so far to the use of computers in education, although the validity of some of Papert's more far-reaching claims about the imparting of transferable problem-solving skills awaits empirical confirmation. In the context of the present paper, there is little doubt that Logo provides what is all too often lacking - a motivational framework which relates to the child's real concerns so that the computer is no longer 'a solution looking for a problem'. Moreover the child is placed in a context in which he or she can discover spontaneously and

with delighted amazement the power of modularity and top-down structuring in programming.

Logo is now becoming commercially available (initially on Apple and Texas Instruments computers) and other systems exist (such as the Xerox Corporation's 'Smalltalk') which have some features in common with it. But even without access to any of these a great deal can be achieved by a teacher who believes in the merit of teaching about modularity and structure. Much can usefully be done away from the computer by classroom discussions and exercises, in which one is called upon to identify and formally specify sub-tasks embedded within complex ones, both everyday and computer-related. No doubt this activity will help children to write better programs, but it should be remembered that this is not the aim, which is rather to provide insight into a way of constructing complex systems in an orderly manner from simple elements.

Conclusion

The approach outlined is tentative and incomplete, and awaits validation in the classroom. But the problem it addresses is a real and important one and it seems worth exploring any avenues that offer a solution.

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COMPUTER-MANAGED INSTRUCTION IN PRIMARY SCHOOLS

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ABSTRACT

Aim

Although computer-managed instruction features less prominently in the subject literature, it appears to be more popular in overseas schools than computer-assisted instruction. The HSRC intends to do research in computer-assisted instruction as well as to determine the advantages of computer-managed instruction.

Nature of project

Modules for Mathematics have been constructed for the whole Std 5 syllabus. The pupils do not communicate directly with the computer but complete work cards in the normal classroom situation.

Structure of project

Each module has five levels of difficulty called A, B, C, D and E. Levels A, B and C cover the whole syllabus and levels D and E are enriching.

COMPUTER-MANAGED INSTRUCTION IN PRIMARY SCHOOLS

INTRODUCTION

On the basis of research into the use of the computer for educational purposes already started by the HSRC in 1974, an *ad hoc* committee of the Committee of Heads of Education on 17 October 1978 decided that experiments with computer-assisted instruction should be continued. This resulted in the HSRC project, Computer-managed instruction for primary school pupils in Mathematics. The aim of this paper is to provide a survey of the didactical side to this project. With regard to the structure of the project, there is a high degree of similarity to computer-managed instruction in overseas countries.

STATEMENT OF PROBLEM

The vital question is still how to make use of the computer in education acceptable to the practising teacher. The answer to this was the choice of computer-managed instruction for two obvious reasons:

- . More pupils in an ordinary primary school can be involved in the instruction with the aid of a single computer than would be the case with computer-assisted instruction. The main consideration here is the cost aspect of computer-assisted instruction.
- . Computer-managed instruction makes the teacher the central figure in the educational events.

AIMS

One of the most important aims of the project is to convince the teacher that the computer can be used to his advantage. For this reason the teachers of the schools participating in the HSRC project have been closely involved in the development of the computer programmes.

With reference to the idea that success in the use of the computer depends on the sympathetic attitude of the teachers, a middle course in the programme has been followed lying between traditional education and more modern ideas with regard to computer-assisted instruction. In the RSA, as is also the case in overseas countries, it can be expected that teachers will reveal a high degree of conservatism with regard to educational methods. It has therefore been decided that the use of the computer should not bring about too radical a change in education at the project schools.

NATURE OF PROJECT

Sixteen modules covering the whole Std 5 syllabus will be developed. As is customary with computer-managed instruction, the pupils do not communicate directly or continuously with the computer but complete work sheets within the usual classroom situation. Answers to exercises are transferred to optical mark sense documents that are marked by the computer. The computer then prints out instructions for each pupil individually, informing him which exercises to do for the next lesson.

MODULE STRUCTURE

Each module has five levels of difficulty A, B, C, D and E. A, B and C cover the whole syllabus whereas D and E contain enrichment exercises. Only the brilliant pupils will do D and E. Each level consists of three work sheets namely a C or computer-scored sheet, a T or teacher-scored sheet and an X work sheet containing remedial exercises. Every module is accompanied by a study sheet.

THREE PREMISES FOR THIS PROJECT

The first premise is that pupils with an exceptional aptitude for Mathematics will be able to cover the easier levels more rapidly, thus arriving at the more difficult levels D and E before their classmates. This means that pupils will be working at different levels on a module during the same period. Pupils will also be differentiated according to the number of remedial exercises assigned to each one. The more errors that are made, the more remedial exercises will have to be done, preventing the pupil from reaching the more difficult levels too quickly.

A second premise is that the educational relationship between pupil and teacher should be preserved. For this reason provision is made for T work sheets that are marked by the teacher and on the basis of which individual aid may be rendered. The teacher may not render assistance when the C work sheets are completed. The reason for this will be explained later. A motivation lesson is given at the beginning of each module to get pupils interested. During these lessons, which are given in a classical context, the teacher should also strive towards establishing a class identity. During this lesson the teacher should take the initiative and he has the opportunity of leaving his personal imprint on the educational events. However, the teacher should not attempt to explain all the concepts contained in a module during the motivation lesson. If the teacher aims at giving an exposition of new content it should be limited to such an extent that the gradual exposition of knowledge in the work sheets is not made superfluous. The teacher may naturally make use of stories, films or similar methods or aids in accordance with his personal style of teaching.

A third premise that is closely related to the second is that the programme should be such that the teacher does not feel that he has to teach according to strict instructions (prescriptive).

For this reason the programme has also been developed in such a way that the teacher can intervene at any time if he is not satisfied with the instructions, thus always remaining responsible for the pupils' activities.

Apart from the aim of establishing the use of the computer in schools for reasons which are already well known, there is also a research aspect linked to the project, namely to determine as far as possible whether this means of instruction will have a significant effect on pupils' school achievement and whether pupils are better motivated by this form of education than by conventional teaching.

A RATIONALE FOR TEACHER PARTICIPATION

A very important method of approach to this project is that the attitude of the participants in any activity is of vital importance to its successful completion. Unmotivated teachers or pupils can yield poor results despite excellent presentation or instruction. Likewise the personal attitude of the members of the team developing the program is vital to the success of the project, for one member can be responsible for the project not getting under way or even being cancelled. Knapper (1978) has also pointed out that students who offer resistance to computer-assisted instruction learn less than through traditional teaching methods (1). Clement (1981) points out that in cases where the attitude of the teachers has been negative, this

has even led to indirect or direct sabotaging of the teaching situation (2).

METHOD OF RESEARCH

Although little research is currently being done to weigh computer-assisted instruction against conventional instruction, the examination results of the five project schools will nevertheless be compared with those of the five control schools. The main emphasis, however, is on action research, which means that the programme will be adjusted according to the results of formative evaluation obtained over the period of four years. It is therefore of great importance that feedback be received from the teachers and pupils at the schools concerned. If it appears that a particular strategy does not produce the desired results, changes will be effected by a work committee consisting of members of the Transvaal Education Department and the HSRC. For the purpose of evaluation teachers and the work committee will have monthly meetings at which the teachers' observations will be discussed. Decisions will also be taken on the basis of questionnaires sent regularly to principals and pupils.

METHOD OF APPROACH

The project is based on the assumption that homogeneous groups do not really exist within the class context and that effective instruction can occur only on an individualized basis. It is also assumed that pupils differ greatly with regard to their ability, interest and preknowledge. Because of differences in learning style it is also logical that all pupils will not derive the same benefit from one specific method of instruction. Although classical instruction has received sharp criticism in didactic literature, it is also realized that used judiciously classical instruction can fulfil an important role in supplementing individualized instruction. Although the project can be regarded as a method of individualized instruction, it is also based on the premise that the social aspect of this project also merits attention. Provision should therefore be made for a group identity and the establishment of a positive pupil/teacher relationship.

THE NECESSITY FOR A THEORY FOR MODULE WRITING

Mitzel (1981) points out the importance of a pedagogical rationale to ensure that educational technology achieves optimal results in education (4). Very often the medium is not accepted because the programme written for the medium does not comply with the requirements laid down for a good learning and instructional situation.

Lipson (1980) points out that the trend to develop computer products that show a fast profit, for example certain electronic games, can seriously affect the potential of the computer for education. Course ware of a poor quality offering irrelevant and undesirable subject material, can give the computer a bad reputation and prejudice interest and investment in more creative applications (5).

According to Mitzel the greatest obstacle to the wide-spread acceptance of computer-assisted instruction is the absence of a relevant educational theory. One of the greatest attractions of computer-assisted instruction is after all situated in the fact that it is the most effective way of putting theory into practice. Other advantages of an educational theory as advocated by Mitzel are the following:

- . A well-articulated theory provides a guide for evaluating the product in that the criteria are defined.

- . A good theory will act as a guide when something unforeseen is encountered.
- . The development team will be able to construct programmes in a disciplined manner, thus ensuring that prejudices and methods traditionally accepted without argument are eliminated. The classroom practices of many teachers are based on traditional techniques preserved by historical inertia. In the ordinary school set-up these practices are of the most difficult to uproot.

The barrier to the adoption of computer-driven systems is the absence of a strong and viable theory of learning. In this regard it can be concurred with Bork (1982) that although the learning process has been intensively studied, there is currently no generally accepted single theory supported by significant empirical investigations(3). Some theories, in fact, evoke the appearance of irreconcilability, for example Ausubel's final form receptive learning and Bruner's discovery learning. The same problem can be experienced with Piaget's operational learning and Ausubel's verbal learning. Learning theories have nevertheless been scrutinized to such an extent that it is no longer necessary to rely entirely upon haphazard methods. Where the work committee of this project has shown certain preferences for viewpoints from various schools of learning theory, it is assumed that in the course of the experiment adjustment will be made on the basis of indications from the practice.

CHOICE OF LEARNING THEORY

Behaviouristic learning theories are seriously questioned by many authors locally as well as overseas (Cf. Greeno and Davis (USA) and locally S. Gouws, RAU and M.C.H. Sonnekus, UP.) According to Spragne (1981) these theories have never been popular with academics and teachers (6). The decline since 1960 in the interest in behaviourism and the subsequent rise of cognitive psychology have compelled the work committee to pay more attention to the theories of the latter. Attention has nevertheless been given to regular feedback and self-activity as important didactic principles. McKeachie's rejection of the principles of repetition and immediate reinforcement is shared by others to a certain degree and these principles are not aimed at in this project (7).

On the basis of the findings of Bloom, Kratwohl and Cagné, particular attention has been paid to objective learning. Mager's point of view is not accepted as testing is not based on objectives in this project. In the light of existing criticism, however, the idea of stating initial objectives on which to base the instruction was abandoned. However, objectives were used in the designing of modules to facilitate task analysis. Objectives were formulated in such a way that the order and nature of the components of the subject-matter can thus be indicated. These objectives were furthermore used for designing the total structure of a module. Objectives were chosen not only according to subject-matter, but also to make provision for the higher-order activities of understanding. Where a choice had to be made between unity of subject-matter and level of competency, preference was given to the latter. The emphasis was therefore placed on context rather than on content. In other words, the same subject-matter used at a less difficult level can be used again at a more difficult level where a higher-order concept is required.

Ausubel's *advanced organizers* were brought to the attention of the work committee and introduced in an amended form in a so-called study sheet. The organizers are regarded as abstracted, generalized and inclusive subsumers. By "inclusive" is meant that detailed knowledge is assumed to be subsumed therein. The purpose of the organizers is to facilitate the subsequent particularized and extensive material assimilation. A further aim is for the organizers to provide pupils with a survey of the work that will follow and to supply the components that will facilitate the integration of the subsequent subject-matter within a comprehensive cognitive structure. Organizers should be selected on the basis of their suitability for explaining, integrating and interrelating the material they precede.

The organizers should provide anchors in terms of concepts with which the pupils are already familiar, thus facilitating their ability to discriminate between new and existing concepts in respect of differences and similarities.

Although McCann (1981) maintains that the four customary strategies, namely pre-tests objectives, surveys and organizers represent different theoretical approaches rather than variations in style (8), the work committee decided to use pretests in the form of a diagnostic test. One reason for this decision was to be able to relate to the pupil's preknowledge in a manner that can be indicated clearly. Another reason was that a large part of Std 5 Mathematics consists of repetitive work. The most important reason, however, was that it conforms with the basic principle of this project, namely that at no stage should subject-matter be presented with which the pupils are already familiar. Neither was it the purpose of the initial diagnostic test to follow it with a comparable post-test.

The mastery of subject-matter is also implemented in the project insofar as pupils receive remedial exercises until in the teacher's opinion they can progress to a higher level of difficulty.

Since Mathematics was chosen for the project particular attention was paid to the Socratic method concerning the principle of learning through discovery. Particular emphasis was placed on the fact that the pupil should not be taught insights that he is capable of acquiring himself. In this respect particular attention was paid to the ideas contained in Wertheimer and Heinrich Roth's theory of productive learning.

In contrast with Skinner's doctrine, it is assumed that pupils learn by making mistakes and the pupil is assisted with simpler concepts only when it is clear that he is not capable by logical steps in thinking processes. Assistance is also given mostly by means of questioning. Neither is remediation following diagnostic tests, given through the breaking up of subject-matter into smaller units, but rather through the reduction of concept to its logical basis so that remediation consists of a logical development towards greater concepts. From this it follows that in the whole composition of the course great care is taken not to present subject-matter already understood by the pupils.

METHOD OF INDIVIDUALIZATION

The methods of individualization aimed at in this project are contained in the whole paper. For clarity's sake the following points are singled out:

- *Tempo variation*: The faster working pupils will reach the higher levels of difficulty more quickly than the slower pupils.
- *Appropriate logical steps in thinking*: Each pupil should be allowed to reason out new concepts for himself as far as possible. For example, Wertheimer points out that the relation between rectangles and parallelograms is sometimes unnecessarily explained to pupils. Since Mathematics has a highly ordered content such an approach is not inappropriate in this subject.
- *Remediation of hiatuses in knowledge*: Pupils differ individually with regard to hiatuses in their knowledge and should receive individual remedial attention.
- *Teacher individualization*: Learning style, anxiety level, interest and inquisitiveness can be handled better by a teacher at this stage.

SUBJECT-DIDACTIC APPROACH

The two approaches to Mathematics instruction, namely the intuitive holistic approach on the one hand and the analytical-systematic approach on the other, both received recognition in the project. In fact, it is this conflict between two competing mathematical philosophical points of view that has characterized discussions on the teaching of Mathematics for the past few decades, which makes these approaches important to this project. The one approach tends towards abstract structures and the axiomatic deductive style of presentation and the other approach regards Mathematics as an activity, stressing intuitive thought as a source of mathematical discovery.

In accordance with the view of Witmann (9) and Fischbein (10), these two methods are not seen as conflicting but rather as supplementing each other. The analytical methods assist in adjusting the primary intuitions and in transforming them into cohesive and productive interpretations. The constructions and operations of reflective thought give rise to conjecture and proof by which a concept is tested. It can also be regarded as a thought experiment in which the operations on examples provide the criticism for inadequate intuition. General consideration is a useful means of testing incomplete intuition.

The idea of an intuitive holistic approach followed by a reflective approach was implemented in two ways. Firstly, problems that can be solved intuitively were given as exercises and others as remedial exercises with indicators for reflective thought. The remedial exercises were presented on a lower level of difficulty. Secondly, problems were given that can be solved intuitively on a low level of difficulty, followed by an analysis of similar problems on a higher level of difficulty in the same exercise series. This will probably prevent a too early focussing on the formal aspects of problem-solving, which can cause wild guessing.

PRINCIPLES UNDERLYING EACH WORK SHEET

Study sheet

The study sheet accompanying each module contains only a framework of the most essential concepts of the theme dealt with in a particular module. No explanations of concepts are given in the study sheet and the pupil uses it as a frame of reference to assist his memory. It is assumed that pupils will use the study sheet particularly when dealing with problems that can be solved only through insight into the wider relation of apparently detached concepts.

C work sheet

The C work sheet contains at the most 20 problems based on a corresponding number of distinguishable objectives. Each of the problems can be preceded by questions through which new subject-matter is introduced. New subject-matter can also be introduced through sketches, diagrams or whatever would be the best method. In the construction of those sheets a deliberate attempt was made, as far as possible, not to convey knowledge directly, on the basis of the premise that the child himself should make discoveries. In the light of the particular degree of original thought required, the construction of the work sheets is a slow and laborious process.

The C work sheet is at the same time used as a diagnostic test according to which the computer gives instructions for subsequent work (rooting). Each pupil receives computer print-outs containing individual instructions.

The T work sheet

In accordance with the principle of socialization, provision has been made for a work sheet allowing the teacher the opportunity of rendering individual assistance and of developing an intimate knowledge of his pupils. The teacher is supposed to mark the T sheets himself, preferably during pupil activities. Although the T sheet should be at the same level of difficulty as the C sheet, it contains exercises with more open-ended answers. The same objectives stated for the C work sheet apply to the T work sheet, but the nature of the questions differs. In the construction of these questions the focus is on questions whose answers are such that they would be difficult for the computer to work.

The computer report

In the computer programme provision is made for the correct answer, an expected wrong answer and an unexpected wrong answer to questions on the C sheet. Appropriate comment is printed on the pupil's report next to the answer given. The comment is given in such a way that the pupil will detect what error he has made in expected wrong answers. This method is based on the assumption that the pupil should not necessarily be provided with the right answer.

The X work sheet

Each objective set for the C work sheet is further analyzed to enable identification of hiatuses in the pupil's knowledge during the development of concept in the X work sheet. Reduction of concept therefore means that the subject-matter is presented on a lower level than was the case in the C sheet.

For every problem in the C work sheet, approximately five questions are set in the X work sheet. Ample explanations and examples are given in the X work sheet. The first four questions of the remedial exercise, which presupposes a gradual development of concept, are marked by the pupil himself. The fifth question is marked by the computer. The question marked by the computer can be regarded as a test to determine whether the concept has been mastered. Theoretically speaking this means that the pupil who has made three errors on his C work sheet must do 15 sums on the X card. However, this idea has not always been implemented in practice as certain subject-matter does not lend itself to being analysed further.

If it appears that even after the remedial exercises the pupil still has not mastered all the concepts, he is referred to the teacher for further assistance. On the teacher report the computer will indicate groups of pupils who are experiencing difficulties with the same concepts. The teacher will then teach certain pupils in small groups. Pupils who make a few errors in the less difficult sums but do the more difficult sums correctly, are transferred directly to the C sheet at the next level of difficulty.

THE TEACHER REPORT

The purpose of this report is to keep the teacher informed on day-to-day progress of pupils. Next to each pupil's name the print-out shows which work sheets have already been completed and in the case of the C work sheets also the number of sums done correctly and the possible total number of correct sums.

CONCLUSION

The requirements with which computer-assisted instruction has to comply in the RSA differ from the requirements laid down in developed countries overseas. Although high priority should always be given to effective instruction, much attention will have to be paid to the provision of cheaper education in the RSA. In Europe and the USA there was a shortage of teachers initially, and the computer was considered as a possible means of solving this problem. However, the situation overseas has changed in the meantime with a swing towards more effective education, bringing about a cost increase rather than a cost decrease.

In the RSA where the emphasis is on equal educational opportunities for all the country's peoples, the lost factor must necessarily be considered. The Black population is experiencing a shortage of teachers and an attempt will have to be made to reach as many learners as possible with the available teachers.

When computer-assisted instruction in the narrower sense of the word, i.e prolonged interactive instruction through a terminal or keyboard, is compared with computer-managed instruction, it is obvious that the latter is aimed mainly at cheaper instruction. Computer-managed instruction has in fact shown that for large numbers of students the additional cost is small compared with the saving in time and labour.

The significance of this project should also be considered in the light of the particular problems of the RSA.

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SOME GUIDELINES FOR THE IMPLEMENTATION OF COMPUTER-ASSISTED INSTRUCTION
IN SCHOOLS IN THE RSA

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ABSTRACT

The use of the computer for educational purposes is a new field in the RSA and many questions still have to be answered with regard to it. In some quarters the use of the computer in education is questioned. However, the impact of technological developments on society and their implications for education indicate that good grounds do exist for such use. A number of guidelines for the implementation of the computer in education are discussed. The formulation of a national policy is regarded as an important prerequisite for the development of an infrastructure for the implementation of the computer in education. Further guidelines discussed deal with teacher training, computer hardware, educational software, support for computer users in schools and research.

1 INTRODUCTION

It is interesting to note that the introductory paragraphs of a large percentage of contemporary articles in journals on the computer in education in overseas countries invariably begin in the same vein. Firstly, reference is usually made to the excitement that prevailed in the first few years about the possibilities (and dangers) of the application of the computer and the dramatic predictions of revolutionary changes that would take place in education within a few decades. Secondly, this is usually followed by a review of the situation a few decades later. The finding is that very few of the expectations were realized and that disillusionment resulted when it became clear that serious problems existed in the use of the computer for educational purposes. Thirdly, reasons are advanced for the computer's still not being accepted and used widely in education until recently. A few examples are the costs involved, the lack of educational software of a high quality and the attitude of teachers.

However, the literature also shows that these developments had a beneficial effect. People began to realize that the computer had limitations but also held great promise for education. The result was that a serious effort was made to study the problem areas and to find solutions. From this a number of dynamic technological and didactic-pedagogic developments resulted, and the situation today is far more positive and realistic. Not all the problems have been ironed out, however, but at least there is an optimistic and realistic approach which brings the effective implementation of the computer one step closer.

This has indicated to us in the RSA the direction that we should take. We are standing at the beginning of a period in which the computer will be used increasingly in education, and we shall have to approach the matter calmly and realistically and not fall prey to the illusion that the computer is the panacea for all our educational problems. There is no doubt that the computer has great potential but a great deal of spadework will still have to be done in the RSA before it can be properly utilized.

2 JUSTIFICATION FOR THE USE OF THE COMPUTER IN EDUCATION

One cannot help asking whether there is any justification for the computer in education. This question is asked against the background of three considerations in particular. Firstly, it is well known that educational aids often arouse little enthusiasm and end up in the storeroom collecting dust. Secondly, there is an unfounded fear that the computer will replace the teacher. The third consideration is far more problematic. In spite of the still declining costs of computer hardware, the introduction of the computer in education in the RSA will entail considerable financial expenditure. When this is weighed against the financial implications of serious backlogs and shortages in terms of physical facilities and staff in education in the RSA, it is understandable that the justification for the computer in education is questioned. Other factors also play an important role in providing an answer to this basic question.

Modern man lives in a period characterized by phenomenal progress in the field of science and technology. Different authors describe this period in the history of man in terms such as the "Space Age", the "Electronic Era", the "Technetronic Age", "post-industrial society" and "super-industrial society", to mention a few. The best known of these is probably the term "Third Wave" which Toffler (11) uses. According to Toffler, the "First Wave" refers to the agricultural age that started in about 8 000 B.C. and the "Second Wave", to the industrial revolution that started in about 1700. Suffice it to say, according to Toffler and other sociologists, that society is on the verge of an era in which its structure is about to undergo drastic

changes. The reason for this is the phenomenal progress in the field of science and especially electronics with the computer as the main component. According to Toffler, this period started as early as the fifties in the USA. The first signs of the new era can be seen in the indispensable role that the computer plays in virtually every field of human activity. As a primary social institution education cannot be isolated from the computer; Shostak(10) even pin-points it as "a particular prominent candidate for root-and-branch revision".

Another matter that goes hand in hand with this is the knowledge explosion of the past few decades. Not only is the technological revolution the result of this explosion but it is also a further stimulant. Molnar(7) is right in saying that man has reached his limit with regard to absorbing and using the vast and growing amount of knowledge. The only way in which the problem can be dealt with is to use the computer as an amplifier of the human capacity to absorb information. Ershov (4) speaks of the computer as an intellectual tool and partner in virtually every sphere of human life and activity. The important point here is the realization that the computer is becoming an essential part of man's life-world.

While the full effect of the technological revolution and the accompanying knowledge explosion will only become known in the (near?) future, the needs of society have immediate implications. Principle 4 of the Principles for the Provision of Education in the RSA, recommended by the HSRC Investigation into Education, states plainly that education should be directed at *inter alia* the needs of society. The signs of the technological era are already clearly visible in South African society. Computer technology is already widely used and its use will increase in future. There is a grave shortage in the RSA, not only in computer personnel, but also of personnel in other occupations which make use of the computer. Every individual will increasingly come into contact with the computer and will have to be acquainted with it. The need in society is that each individual should be prepared for this. Education, as an institution that was created by society, was intended to prepare the child for a meaningful adult life and it is therefore education's function to familiarize the child with the computer. If education does not do this, it will lose touch with and become irrelevant to the society it serves. Burnham (1) talks of the gap between the school and reality and sounds a serious warning: "Education may be counterproductive if it is out of touch with what is really happening in the world, or if it becomes merely reactive, being shaped, instead of shaping or being by-passed as obsolete and irrelevant."

The question now arises as to what the implications are of the technological era and of everything related to it for education and the school in particular. Two implications are particularly significant. Firstly, on account of the knowledge explosion and the limited abilities of the human being, the teacher will no longer be able to act as a primary source of knowledge in the classroom. This means that the teacher will have to use the computer as an information source and that the traditional role of the teacher will therefore change. The second point that has implications for education is the fact that the computer is becoming an intrinsic of man's life-world. It now becomes the duty of the school as a societal institution to teach the child about the computer and make it part of his life-world. In this regard Ershov (4) speaks of computer literacy or programming as he calls it, as the second literacy in addition to language literacy. In support of his argument he points out that

- . language literacy and computer literacy are both based on technological inventions, namely the printing press and the computer;
- . both literacy and programming give expression to the organic ability of man as displayed in all social functions of people, in communication, work, the contemplation of nature and the struggle against it, and
- . literacy and programming are not only analogous - they also complement one another, forming a new harmony in the human mind.

From this it follows that the school of the future will also have to regard computer literacy, together with language literacy, as part of its responsibility.

In seeking an answer to the vital question as to whether there is justification for the computer in education, a study was made of the technological era towards which society is moving and its implications for education. Apart from these external factors, internal factors in education itself can also justify the use of the computer. Without going too deeply into the matter, a few examples can be given:

- . The shortage of teachers at different levels and in certain subjects.
- . the provision of equal educational opportunities, and
- . the sharp rise in the cost of providing conventional education.

The implications of these factors compel Ershov (4) and many others to say: "The question of whether or not computers should be allowed into schools is becoming somewhat scholastic these days, following the emergence of micro-processors. Computers have already found their way to schools and will pour there in ever growing numbers. What is required now is a concerted intellectual and organizational effort to direct this process into a controlled and educationally viable channel."

This brings us to the following question, namely how the implementation of the computer in schools can occur in a co-ordinated and educationally viable way.

3 GUIDELINES FOR THE IMPLEMENTATION OF COMPUTER-ASSISTED INSTRUCTION IN SCHOOLS

A few guidelines will now be discussed and although they are directed at the implementation of computer-assisted instruction, they are also related to other applications of the computer in education. Computer-assisted instruction in this context means the use of computer technology in the educational situation as an educational aid, i.e. as instructional or learning aid, with drill and practice, tutorial, problem solving, simulation and games as a few of the uses.

3.1 FORMULATION OF A NATIONAL POLICY

Probably the most important guideline for the implementation of computer-assisted instruction in schools in the RSA is the formulation of a national policy. Education departments will have to pay serious attention to this and formulate a policy that will give clear guidance to schools and will indicate the direction for the future. The fact that the RSA has only just started with the investigation and application of the educational possibilities of the computer, has the advantage (among the disadvantages) that it presents an opportunity to plan and co-ordinate the implementation of the computer in schools properly from the start. The fact that many schools have already purchased microcomputers or intend doing so in the near future, emphasizes the need for the formulation of a national policy as a matter of urgency. The only guidance these schools have at present is provided by commercial computer dealers.

A prerequisite for the formulation of such a policy is an understanding of the general nature and educational possibilities of computer technology and expected developments in this field. The alternative approaches and the resultant implications of each would have to be studied and considered carefully (1).

The policy would have to give guidance in matters such as the training of teachers, the choice and provision of computer hardware, the development of educational software, support to computer users in schools and a strategy for the implementation of computer-assisted instruction in schools. In other words, it would have to provide guidelines for the establishment of an infrastructure for the implementation of the computer in education in the RSA.

3.2 TRAINING OF TEACHERS

The training of teachers in the use of computer technology will naturally have to receive high priority. The views on the various functions of the teacher and the computer in computer-assisted instruction have important implications for teacher training. The point of departure here is, in the first place, that the computer is used in the educational situation as an educational aid, i.e. as a teaching and learning aid, by the teacher and is therefore supplementary to the teacher. There is therefore not the slightest possibility that the computer will replace the teacher. In the second place the computer is seen as one of a number of media the teacher can use to assist him in his teaching task. There are some educational problems that the computer can help solve and others that it cannot solve. Appropriate use of the computer is therefore of primary importance in computer-assisted instruction (9).

The function of the computer in computer-assisted instruction is, on the one hand, to serve as a medium for the presentation of subject matter in a particular form and in particular circumstances, and on the other hand as a means by which the subject matter can be applied. In contrast, the teacher's function in computer-assisted instruction is to initiate, to co-ordinate and to control the learning activities. This means that the teacher must be fully acquainted with the possibilities and limitations of the computer as an educational aid. This does not imply that an in-depth knowledge of the computer is needed to use it effectively, although such knowledge will make the teacher less dependent on specialist support (9). A term that is perhaps appropriate here, is computer literacy. It means, primarily, that training should enable the ordinary teacher to use the computer appropriately and effectively in the lesson situation.

The use of the computer for education purposes also requires the expertise of specialists. For instance the development of courseware is a specialized task that demands detailed knowledge of didactic theory, a particular subject and computer-programming. Teacher training will also have to make provision for the training of these specialists.

The training of practising teachers can be done by means of in-service training courses and in other ways. There is, however, an urgent need for university courses that offer comprehensive training in the use of the computer for educational purposes. This urgency is related to the fact that little has been done up to now in this respect in the RSA. The result is that, on the eve of the implementation of the computer in schools, there are few properly qualified experts who can give guidance.

The co-operation, enthusiasm and conviction of the teacher are regarded as of the utmost importance for the successful implementation of computer-assisted instruction.

Training will make an important contribution to the realization of this prerequisite. On the one hand it will neutralize the unfounded fear that the computer will replace the teacher. On the other hand the enthusiasm of well-trained teachers and the successful results obtained will have a ripple effect and more and more teachers will be convinced of the possibilities of computer-assisted instruction.

3.3 HARDWARE

During the first educational applications of the computer overseas, use was made of network systems in which a number of educational institutions such as schools were connected to a large central computer via telecommunication lines. The PLATO system which still provides excellent facilities today is a good example of this. As far as schools are concerned, the provision of computer facilities in this way is expensive, mainly due to the ever-increasing cost of telecommunication lines. When the minicomputer with its smaller network was developed the problem was partly solved, but the real breakthrough only came with the appearance of the relatively cheap stand-alone microcomputer. For the first time the possibility of using the computer widely in schools became a reality. However, certain facilities can still only be made available if a network is used. The electronic "down loading" of educational software from a central source to schools is one of them. Consequently the latest trend is to think in terms of a local network of microcomputers at a school, with the facility to connect to a remote central computer as the need arises. Such a system not only has the advantages of the microcomputer, but also those of the network system, while it has few if any of the disadvantages of both systems.

In the RSA it must be accepted that the microcomputer will find its way increasingly into the schools. With the availability of a great variety of such computers, a problem could arise in that the various microcomputers and their software are not mutually adaptable or transferable. This brings us to the controversial question as to whether microcomputers should be standardized in schools or not. According to requests that have reached the Human Sciences Research Council from various quarters, it appears that this problem is already being experienced in the RSA. The first question that arises is whether standardization can be justified. The implications of non-standardization are that various types of microcomputers will be found in schools. This in turn means that the institution rendering assistance to schools will have to provide software and other support services for each type of microcomputer. This will not only cause a serious logistical problem, but will also result in unnecessary duplication and ineffective use of limited resources. This leaves us with no alternative but to standardize. The question now is how this can be achieved. In the light of the free enterprise system with its competitive element, it must be accepted that an agreement between manufacturers of microcomputers to standardize hardware and/or software will not be possible. The only remaining alternative is to standardize by recommending a particular microcomputer for schools. Various countries and states in the USA follow this system. For example the Minnesota Educational Computing Consortium (6) evaluates all the available types of microcomputers in respect of a number of criteria in order to be able to recommend a specific microcomputer for schools.

Although the costs of microcomputers will decrease in future in relation to their capabilities, their provision to schools will still be very expensive. Schools that want to purchase microcomputers on their own initiative and from their own funds, should be encouraged and supported in some or other way. There is a danger, however, that this will lead to an unequal distribution of microcomputers since the schools in the well-off communities will be better able to afford them. In the light of the principle of equal educational opportunities that was recommended in the HSRC Investigation into Education (8) as a guideline for an educational dispensation for the RSA, such unequal distribution will be totally unacceptable. The National Education Association of the USA (2) warns that "in terms of equalizing educational opportunity, the gains of the past 15 years may be wiped out in two or three years by the present uneven use of microcomputers for instruction, largely in selected and privileged schools". Shostak (10) points out that it may even widen the gap between the well-off and the poorer communities. It is therefore clear that schools that cannot purchase microcomputers from their own funds will have to receive direct financial aid. Apart from this, schools

will save a lot of money if a central institution representing schools could arrange a favourable purchase agreement with microcomputer dealers. The Minnesota Educational Computing Consortium(6) has done so successfully.

While planning for the future it must be kept in mind that dynamic developments will always occur in the field of technology. The video disc, which integrates the computer and video technology and has far-reaching educational possibilities, is a good example of this. It would however be a serious mistake to delay the implementation of the computer in schools until the "ultimate" educational technology medium has been developed. There is no guarantee that technology will ever reach such a stage and if it does, an ineradicable backlog may in the meanwhile have developed in education.

3.4 EDUCATIONAL SOFTWARE

It is generally accepted that the shortage of courseware and other educational software of high quality is at present the greatest shortcoming in the use of the computer for educational purposes. The reason for this, on the one hand, the fact that the development of educational software is a highly specialized, time-consuming and expensive undertaking. On the other hand, from a didactic-pedagogic point of view, there is no certainty yet about the way in which the computer can be used optimally in education.

There are mainly three possibilities for obtaining educational software:

- . A team of four different specialists can develop educational software on a centralized basis.
- . Practising teachers can develop their own educational software.
- . Educational software which is commercially available can be purchased.

Up to now the team approach has been the most successful in the development of high quality courseware. Such a team consists of a subject specialist, an instructional designer, a programmer and a documentation specialist.

Practising teachers have so far achieved limited success in the development of their own educational software. The main reason for this is, on the one hand, the specialized nature of the software and on the other hand the fact that teachers usually do not have the necessary specialized training. In order to solve this problem the trend is to develop authoring languages and systems. With an authoring system it is much easier for a teacher to develop educational software since he does not have to use the programming language directly. Naturally teacher training will also contribute considerably to the solution of this problem.

The purchasing of commercially available educational software has great possibilities although there are also serious problems attached to this practice. A large percentage (up to 80 % is mentioned) of the commercially available educational software does not comply with the requirements for educational use. An important reason for this is that the authors of this software frequently have very little or no didactic insight into the use of the computer for educational purposes. To overcome this problem the latest trend is to establish clearinghouses which evaluate the educational software properly, document and disseminate it.

As far as the development of effective educational software in the RSA is concerned, the training of teachers and specialists will be of primary importance. Consideration will also have to be given to institutions that can undertake this specialized task.

3.5 SUPPORT

In the few guidelines already discussed, reference has repeatedly been made to the support rendered to the teacher in the use of the computer. This assistance, which is of primary importance, can only be rendered successfully by some or other institution outside the school, owing to its nature and scope.

The Minnesota Educational Computing Consortium (6) is once again quoted as a good example. This organization and its member organizations co-ordinate and provide computer facilities and supportive services to schools throughout the state of Minnesota. A number of regional information centres have been established in England under the guidance of the Council for Educational Technology (3) to perform this task. According to these organizations, this assistance can be classified into five general categories:

- . The purchasing, installation, maintenance and documentation of the computer system.
- . Training in system operation, use of application packages, and programming languages.
- . The acquisition, conversion, development, maintenance, documentation and dissemination of educational software.
- . Response to questions, problems, and requests.
- . Dissemination of relevant information on the use of computer technology in schools.

The question is which institution in the RSA can offer this assistance. Currently there is no institution that has all the necessary expertise and facilities. Education departments will have to get together on this matter and, if necessary, initiate the establishment of such an institution. Universities can also play an important role in the provision of some of these supportive services. Two important items here are training and the development of educational software.

Communication media are needed to convey information on the computer in education. The large number of periodicals published overseas on the subject are proof of this. In view of the current interest it is high time that a similar periodical appeared in the RSA.

3.6 RESEARCH

For education in the RSA, the use of the computer is a new field in which very little experience has been gained. Naturally much research will have to be done and this will mainly involve universities and research organizations.

Research into this subject can be divided into two general categories:

- . Research to "prove" the justification for and the effectiveness of the computer in education.
- . Research into all aspects concerning the optimal use of the computer in education.

The first category has been studied intensively overseas during the past two decades. Gleason's (5) findings in regard to research in this category are significant: "..... few serious researchers are now interested in comparative studies, i.e. studies which attempt to compare the results of computer-assisted instruction with the results of other strategies, either unique or 'conventional'. The futility, or perhaps fallacy of comparative studies lies

in the extreme difficulty of controlling the large number of significant variables which interact in most instructional settings."

The recommendation made here is that the justification for the computer must be "accepted" and that research in the RSA must be aimed particularly at the optimal use of the computer in education.

SUMMARY

Computers and especially microcomputers are already appearing in schools in the RSA. We now have to guide this initiative. The RSA has the unique opportunity to plan and execute the implementation of the computer in education from the outset. The formulation of a policy that *inter alia* makes provision for the development of an infrastructure for the implementation of the computer in education in the RSA, is necessary. The fact that there may be difficulties ahead should not cause us to hesitate. What we need to do now is approach the matter realistically, gain experience and learn from it so that education will be able, by making the best use of all the means at its disposal, to comply with the future demands of society.

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SOUTH AFRICAN SECONDARY SCHOOL CURRICULA DEVELOPMENT PROGRAM

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ABSTRACT

The urgent need for trained and skilled personnel is reaching crisis proportions in South Africa. More and more companies are beginning to attempt to upgrade Black employees to higher level technical jobs. A major impediment to that effort has been a lack of basic and high school level academic skills. A major requirement which serves as a prerequisite for further training and development is academic courseware at the high school level.

In 1980 SASSC - the "South African Secondary School Curricula" development program was initially planned. SASSC is a major effort to develop high school courseware needed to meet education and training needs in South Africa. The PLATO[®] system is being used for delivery. In 1981 the "PLATO COURSEWARE TEAM" undertook to implement this program using the following strategies:

Curricula Design

The initial subjects selected for development are:

English
Mathematics
Physics and Chemistry

These subjects were identified as having the highest priority. Curricula

in each subject were subdivided into courses and modules. Learning and instructional objectives were initially obtained from the NSC (National Senior Certificate) Standard 9 and 10 syllabi.

Curriculum Development

A two-phased approach has been used in developing the SASSC curricula. Phase I has included:

1. specification of a curriculum structure for each subject using the PLATO learning management system (PLM),
2. preparation and entry of test questions and feedback messages to enable diagnostic testing under PLM, and
3. the selection of existing PLATO lessons and textbook reference readings to serve as learning resources.

The aim of Phase I has been to develop computer-managed curricula that combine excellent diagnostic testing and the best available existing instructional materials. The Phase I curricula can be tested with students from the target population to begin meeting their education needs and to provide the development team with feedback useful for curriculum enhancements planned for Phase II.

Phase II will build upon the PLM structure and diagnostic testing set in Phase I. Additional management strategies will be established to adapt the computer-managed curricula to different levels of study and implementation environments. Major emphasis will also be given in Phase II to the upgrading of the learning resources used to support the curriculum. This will include the adaptation of existing PLATO lessons, the development of new text readings, and the development of many new PLATO lessons.

THE IMPORTANCE OF DEXTERITY IN MANIPULATIVE SKILLS IN THE EARLY STAGES OF AL-
GEBRA LEARNING. A CATASTROPHE THEORY MODEL

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ABSTRACT

Any natural phenomenon controlled by two factors can be represented by a cusp-shaped three dimensional manifold known as a "cusp catastrophe".



The pattern in the early stages of learning Algebra, is of this shape and is qualitatively the same for all pupils.

The achievement of a pupil (x) is controlled by implementation of the curriculum (a) on one hand and practice in manipulative skills (b) on the other hand.

The model suggests that if manipulative skills are neglected in Stds. 6 & 7, the pupil will have great difficulty in achieving in the senior classes.

The personal computer can substitute for the teacher in this tedious task, and liberate him to concentrate on presenting the curriculum.

1. Introduction

In his book "Why the professor can't teach" Morris Kline writes:

"Of course, the New Math in the United States was a disaster at both the elementary and secondary levels. When students could not add 8 and 9, almost everyone was shocked. That a High School student could not solve $X + 3 = 7$ should have been equally shocking, but since the solution of this problem is beyond most adults anyway, the failure to master Algebra was not attacked as severely". [1]

As with the results of the doctrine of Dr. Spock, it will require at least a generation to remove the ruins of the disaster. In the Republic of South Africa one wonders whether we have started to remove the cause of the disaster.

Professor Kline continues [1] :

"It is a profoundly erroneous truism that we should cultivate the habit of thinking of what we are doing. The precise opposite is the case. Civilisation advances by extending the number of important operations which we can perform without thinking about them. Operations of thought are like cavalry charges in a battle - they are strictly limited in number, they require fresh horses and must only be made at decisive moments".

In this paper I will try to "prove" by means of a mathematical model that if we heed Professor Kline's warning and use less "reason" but more "rote" in our Mathematics teaching, we will at least begin to prevent more disasters.

Achievement

Consider the factors which influence the achievement of the pupil in the St. 6 Algebra class. Achievement is a direct result of success at learning. The most important factors are

1. Intelligence
2. Social & domestic background
3. Classroom Conditions
4. Homework

By the time the pupil enters High School the teacher can do nothing about the first two. There remains for the educator then two factors - Presentation of the curriculum in the classroom, and the practice of manipulative skills either in the same environment or at home (or perhaps in the future in computer centres)

I will now try to establish a qualitative model of the effect of these two factors on achievement.

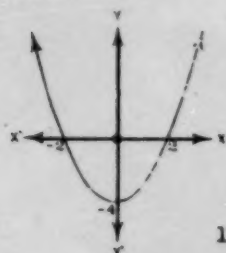
3. Homeomorphic Shapes: (Homeo = The same; Morph = Form)

The path described by a projectile moving freely under the influence of a gravitational field will always be parabolic in form. This is a qualitative statement. It can only be made quantitative if we analyse the motion and derive a formula of this type:

$$\{(x; y) / y = x^2 - 4\}$$

Once the motion has been quantified a graph can be drawn (Fig. 1a). The other graphs describe this type of movement qualitatively.

Fig. 1b - 1c



1a.



1b.

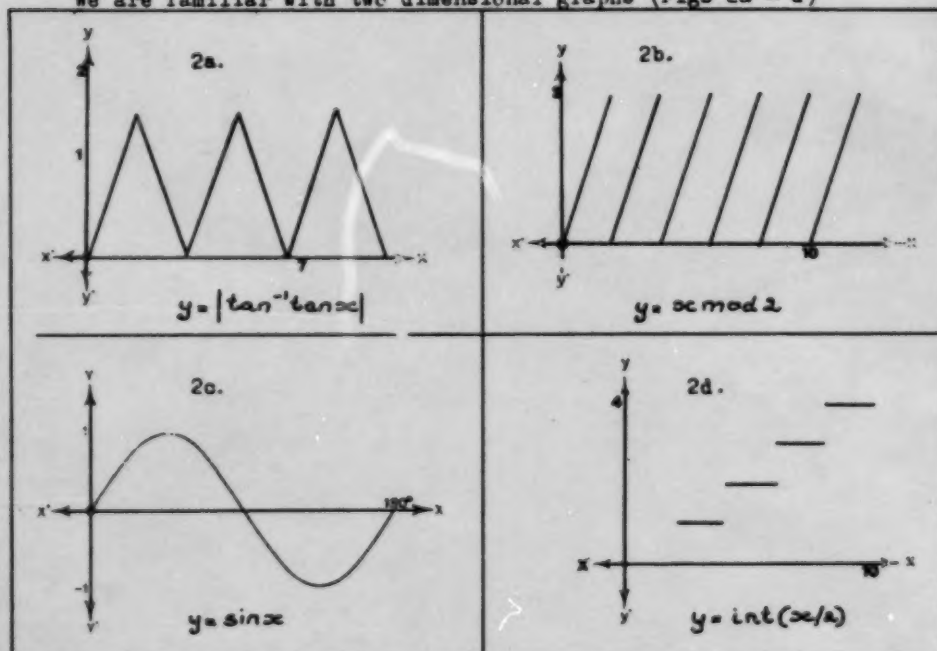


1c.

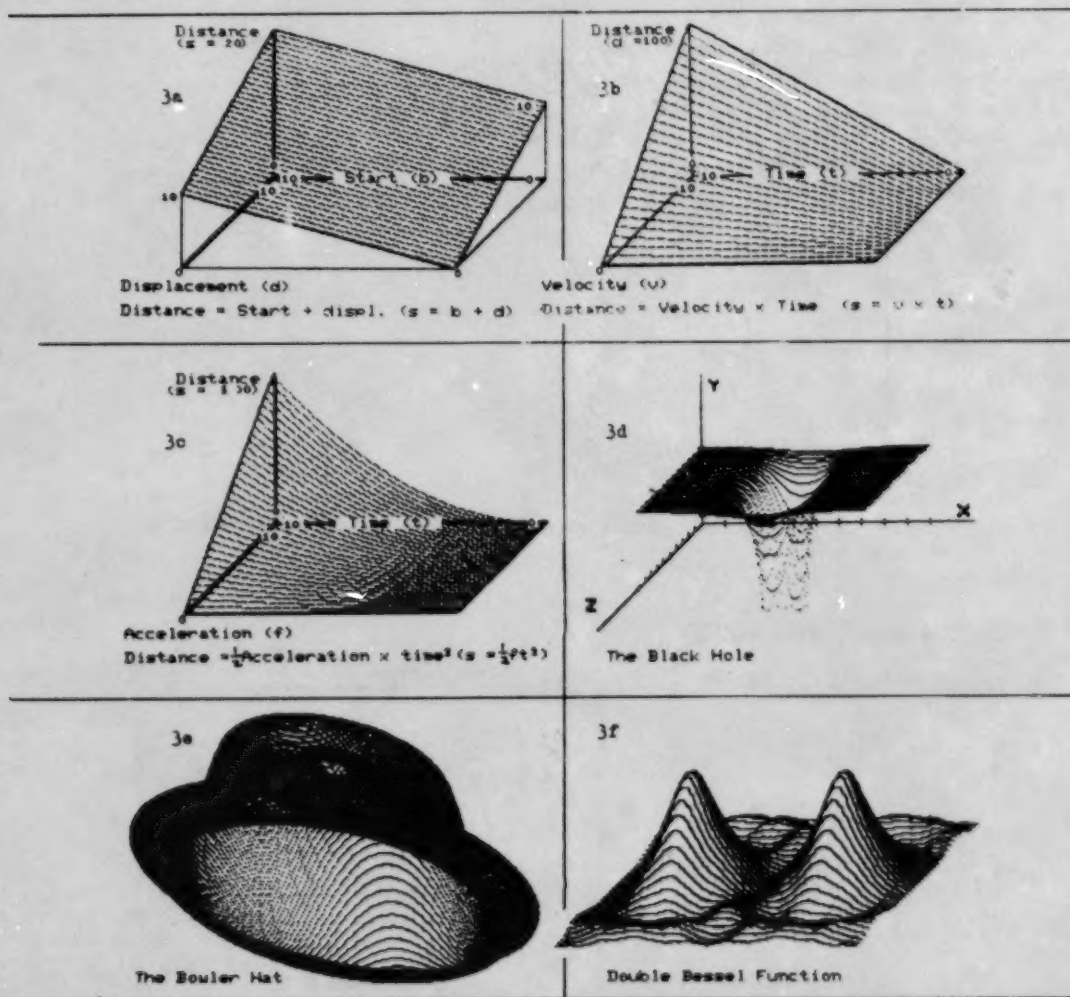
Even though a qualitative graph cannot predict "where" and "when", it can show trends.

4. Three dimensional graphs

We are familiar with two dimensional graphs (Figs 2a - d)



Three dimensional graphs are not so well known. A third dimension (y) describes the behaviour of two control factors (x and z). This means that a transaction is being initiated on a plane (xz) by variation in control values of x (along X) and z (along Z) and the result is a behavioural surface (or manifold) in the y - direction (Figs 3a - f) [2-]



It would have been easy if all surfaces were functions, i.e. if for each pair of values of x and z a unique value of y would be mapped as is the case for all the graphs in Fig 3.

Unfortunately the matter is more complicated in real life.

5. Catastrophe Theory

Even though the principles of stability had been studied as early as 1945, [17] it was only in the early sixties that a brilliant French Mathematician René Thom noticed the homeomorphic character of shapes and behaviours in nature. In [4] Woodcock and Davies write:

"Because of the persistent recurrence of similar forms which Thom observed in nature, he believed that there was a limited number of structures .. but he could not prove it. Another French Mathematician, Bernard Malgrange, proved in 1964 that for a wide range of processes only seven stable unfoldings, the seven "elementary catastrophes" are possible."

Although qualitative in nature, the flavour of Mathematical rigour to a theory which models discontinuous behaviour in nature caused a furore when Thom published it in 1975 [5], and applications of the theory by E.C. Zeeman followed soon after. [6]

The attention of the English public was drawn to the theory by [7] towards the end of 1975 and that of America by [8] early in 1976. For nearly a year the war of words raged in academic circles [9 - 12]

Such was the impact of morphogenesis (the origin of form) and Catastrophe Theory that "two biologists of the University of Sussex, Brian Goodwin and Gary Webster are this year publishing a formidable onslaught on Darwinism" [18]. They argue that in the same way as gravitational fields can direct the path of objects "at a distance", so biological fields can direct the evolution of forms "at a distance"

Further discussion of the theory is limited to the case of two control factors and one behavioural surface.

6. A Simple Catastrophe

In one of the simpler cases of Thom's Theory Malgrange proved that subject to two control factors only one possible behaviour surface can exist.

Condensed by Woodcock and Poston in [13] the mathematics of the Theory reduces to:

"The Generalized Potential Energy Function of the cusp is in the form:

$$V = \frac{x^4}{4} - a\frac{x^3}{3} - bx$$

Stationary or Stable (maxima or minima) values of this equation occur where:

$$\frac{dV}{dx} = x^3 - ax - b = 0$$

Although the theory is intended as a qualitative theory, I will quantify to illustrate.

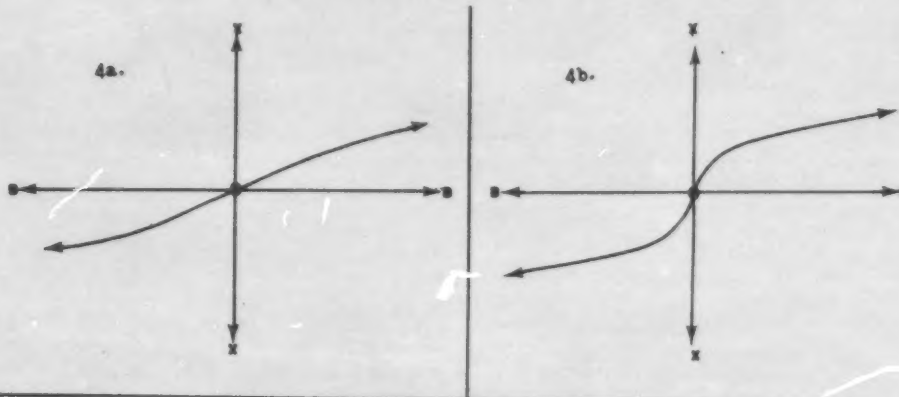
7. The Cubic:

For $a = -6$ the Energy Function stabilises for $\{(b; x)/x^3 + 6x - b = 0\}$.

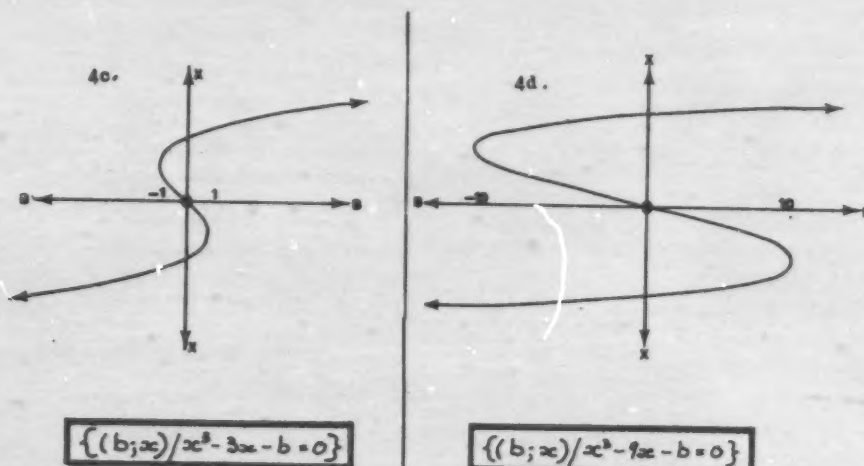
which is a simple two dimensional graph for the interval $b \in [-12; 12]$ (Fig 4a). In this interval there will always be one real and two imaginary roots for the equation.

For $a = 0$ the Energy Function is stable for $\{(b; x)/x^3 - b = 0\}$.

In the interval $b \in [-12; 12]$ the graph is Fig 4b.



For $a > 0$ the Energy Function will sometimes have three real roots in the interval $[-12; 12]$ and the graphs for $a = 3$ and $a = 9$ are shown. (Fig 4c - d.)



8. The Cusp

If the composite three dimensional graph:

$$\{(a; b; x)/x^3 - ax - b = 0\}$$

is constructed from layering the separate sections, obtained by the values of a in the interval $[-6; 9]$, the cusp is obtained. (Fig 5a)

According to Thom's Catastrophe Theory therefore, any behaviour subject to two control factors MUST be in the shape of this cusp.

Zeman explains: "Whenever the fold curve is crossed, the behaviour jumps between top and bottom sheets, the middle sheet is inaccessible. [14]"

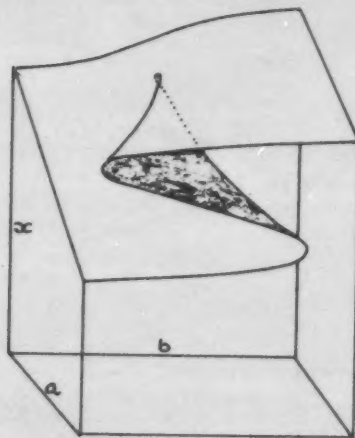


Fig 5a

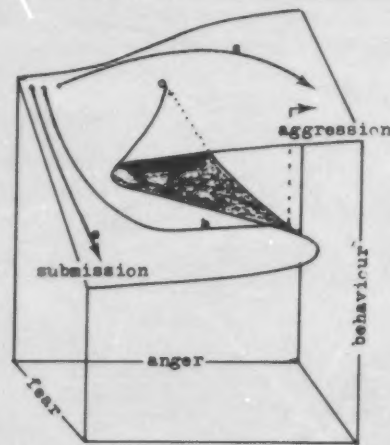


Fig 5b

9. Psychological Application

If the behaviour of a child in a classroom situation is influenced for a brief span of time by factors evoking fear and/or anger (as by punishment), the resulting behaviour would be somewhere on a spectrum ranging from submission to aggression (Fig 5b)

If a pupil has been conditioned towards constant submission, he will automatically submit (a), provided he is not placed under excess stress in which case he will go into a sudden tantrum (b) [15] The path (c) under similar circumstances is mapped for a child raised in the permissive way. [16]

10. Biological Application(1) Boy meets Girl:

The popularity achieved by a boy on first meeting a girl, can, apart from his natural talents, be greatly influenced by his "approach". This model shows how far he "makes it" if his approach is controlled by "Boldness" as one factor and 'Courteousness' as the other. (Fig 6a)

The path (a) is that of the Tarsan type lover who bungles at the outset and then tries to make up with flowers or gifts. **Warning:** Only a catastrophe in the form of a sports car can remedy such a blunder.

A caution to lovers and husbands: Note the catastrophic drop if you forget the birthday, or anniversary flowers! (b)

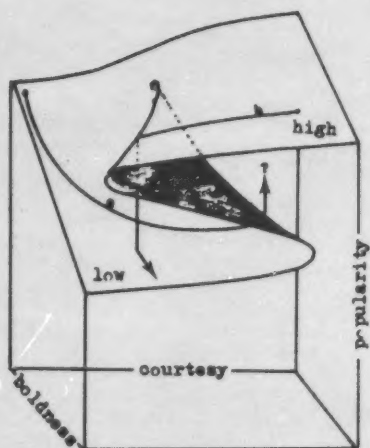


Fig 6a

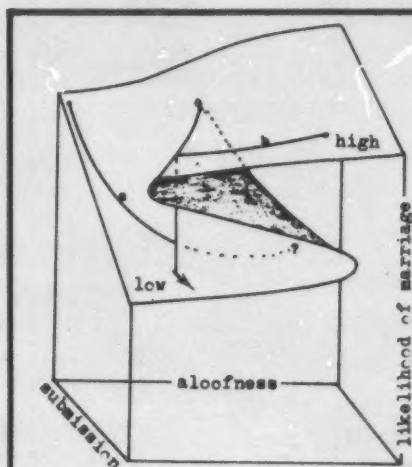


Fig 6b

(11) Girl meets Boy:

Note path (a) of the girl who "throws" herself at a boy. Only a miracle can help her if she really wants him for a husband. The model (Fig 6b) speaks for itself. Note the catastrophic drop (b) for the woman who "gets" her man and then thinks that she can keep him for life while she degenerates mentally and physically without any effort to improve her image.

11. The Algebra Classroom:

In Section 2 I limited the factors which control the achievement of pupils in the St. 6 Algebra class to "Classroom Conditions" and "Practice"

Under "classroom conditions" I leave it to the reader to substitute his own. A few I can suggest are "in depth explanation of the work"; "passage of time"; "inspiration imparted by the teacher"; "threats by the teacher" or simply "doing the curriculum in chronological order". The other factor "practice", "homework" or "dedication", for my model I will define as "dexterity in manipulative skills".

My simplified model therefore is one where the achievement of the St.6 pupil in the Algebra class is controlled by the implementation of the curriculum on one hand and practice of mechanical skills on the other (Fig. 7).

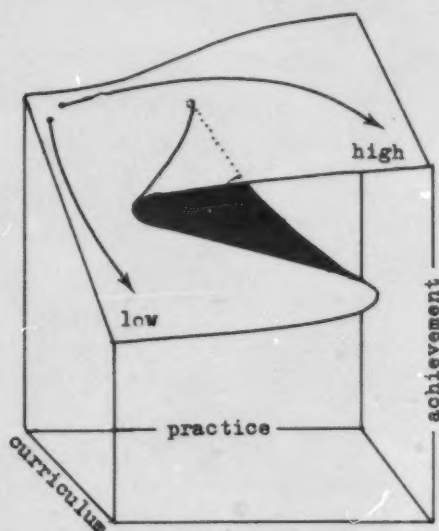


Fig. 7

The model suggests that if drillwork is neglected in the first two years of Algebra the pupil passes the bifurcation point and lands on the level of low achievement. If however, he passes this point on the upper achievement level, he can remain there by maintaining reasonable exercise. His achievement, however can drop drastically (catastrophically) if at any time in his high school career he neglects practice in manipulative skills.

To achieve this we must re-assess the position of the New Maths in the syllabus and consider refraining from trying to explain difficult laws and principles until such time as the pupil can perform the elementaries without distracting from his operations of thought.

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COMPUTER-BASED EDUCATION IN A SOUTH AFRICAN ADULT EDUCATION CENTRE
THE FIRST SIX MONTHS

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ABSTRACT

In 1981, St. Anthony's Adult Education Centre became the first adult education institution in South Africa to use PLATO computer-based education.

The paper explores some of the problems faced by the population of that Centre - notably lack of time - and describes some of the steps taken to redress them by means of education technology.

Subjects in which traditional teaching was supported by PLATO include Physical Science and Mathematics, Biology and English at high school level, university chemistry, and commercial subjects.

Introduction

The venture undertaken by Control Data (Pty) Limited and St. Anthony's Adult Education Centre in which a 16-terminal PLATO computer-based education (CBE) centre was installed at the St. Anthony's educational complex was without precedent in South Africa. In fact, it was without precedent anywhere in the world. In view of the unique nature of the South African education situation and the peculiar needs of its adult students, experiences from other projects (1-11), while interesting were not necessarily informative, nor were they necessarily good predictors of the problems that have had to be faced at the St. Anthony's project.

What follows is an attempt to share some experiences that may be of value to others who introduce innovations - especially advanced educational technology - into similar institutions. While there is, of course, much that is described below that is unique, it is probable that there will be sufficient that is generalisable for other people to benefit from this exposition.

Evaluation

This paper represents a small and somewhat hesitant first step in an evaluation of the CBE project at St. Anthony's. Numerous project reports and papers were studied and various evaluation models were considered (12-14). For a variety of reasons, the author inclined away from a more traditional objective approach to evaluation towards what Stufflebeam & Webster (14) refer to broadly as "values-oriented" studies. The reaction that has developed in recent years against over-restrictive approaches to evaluation is possibly best typified in Parlett & Hamilton's (13) classic paper which advocates the use of alternative evaluation techniques that owe more to anthropology than to science.

Accordingly, this work does not attempt to measure student progress using statistical techniques, nor was any attempt made to use control groups or to compare CBE with other media of instruction. In style, the paper is largely historical-narrative, not dissimilar to that of House and Gjerde (6) and based on a position of admitted bias (the author being the project consultant assigned to St. Anthony's). As the period under review was so short, there is little basis for drawing valid conclusions at this early stage but a description of the processes undergone and the lessons learned may be of interest.

Historical perspective

The introduction in 1981 by Control Data (Pty) Limited of its PLATO computer-based education system at St. Anthony's Adult Education Centre followed over two years of contact, negotiation and fund-raising. St. Anthony's was, by then, a well-established institution whose growth began in 1965. Starting in a small way, the complex grew so that seventeen years later it accommodates thousands of students and is the parish church for Roman Catholics from the local "coloured" community of Reiger Park. The complex is also used as a community centre.

Control Data Corporation has for years been actively involved in social responsibility projects in the United States and the Chairman and Chief Executive Officer, Mr. William C. Norris, saw the introduction of PLATO in South Africa as a means of assisting disadvantaged people in that country also.

In assessing where in South Africa PLATO learning centres should be located, local Control Data personnel considered such factors as existing administrative infrastructure, educational excellence, accessibility for support staff, the potential for the Post Office to instal the necessary dedicated telephone lines, acceptance of the institution by the student population and the community at large and - most importantly - whether computer-based education would fulfil any educational need. In all respects, St. Anthony's, which is on the outskirts of Boksburg, on the East Rand, about forty kilometres from central Johannesburg and close to a major mining and industrial area, was extremely suitable.

Time

Before Control Data committed itself to installing a computer-based education centre at St. Anthony's, a thorough analysis of educational need was undertaken. The most pressing problem that emerged in that study was that of time, which for adult students is always very limited. In fact, it was estimated that adult students enjoyed only about a quarter of the teacher-contact hours that full-time students received. To aggravate matters, some students were shift-workers which meant that very often, even the few teacher-contact hours that they might have experienced were lost. Thus, it was reasoned, a facility such as PLATO, could have enormous advantages if suitable courseware were available, as it offered self-paced tuition of a consistent standard at any hour of the day or night that the system was functioning.

In the light of this and other considerations, - not the least of which was the enthusiasm of the authorities at St. Anthony's - a decision was taken to seek funding for the project.

Funding the Centre

The cost of constructing and equipping the floor of the building that housed the computer-based education centre was provided by overseas donors in response to a personal appeal by the Manager Public Affairs of Control Data (Pty) Limited and by Father Stan Brennan, the Parish Priest at St. Anthony's. Major donors have promised to assist with meeting the continuing cost of running the project.

Staffing at St. Anthony's

The computer-based education centre was staffed by a Control Data project consultant, who had external responsibilities as well, a site manager, who was seconded temporarily by Control Data with a brief to train staff and oversee activity in the centre; an assistant who was on the St. Anthony's payroll and a Priest, who was designated as director of the centre.

The Adult Education Centre was staffed by a relatively small number of full-time personnel. There was a principal and a vice-principal (both nuns) who were supported by several lay administrative staff, some of whom also taught in the evenings. A third nun had charge of the secretarial students. The Parish Priest was not directly involved with actual educational matters.

Teaching in the Centre was largely done by volunteer, part-time teachers. As the Centre was subsidised by the Department of Education and Training (this because the students were predominately black) the teachers were paid by the hour by the Department.

This structure resulted in certain problems. While the dedication of all members of staff was beyond question, the system caused the difficulties. There was little professional contact between the part-time teachers : such as there was, being largely informal. There were, for example, no senior teachers to co-ordinate the work of others. It was quite possible for a teacher to arrive at the Centre, teach her class and return home without even seeing another teacher, especially as many teachers arrived only just before lessons started at 19h00 and departed soon after the close.

This had major disadvantages for an innovatory programme such as the one under consideration. In institutions where members of staff worked full-time and there was a more conventional authority-hierarchy, responsibility for the introduction of an innovation could be vested in particular members of staff. By means of staff meetings and discussions, the innovation could be explained to the teachers. Those interested could volunteer for or be assigned duties such as development or evaluation of courseware, integration of the innovation into the curriculum and other associated matters. With a staff-structure such as that at St. Anthony's, this was impossible.

Explaining the innovation

Nevertheless, the teaching-body had to be kept informed about the project (in a non-threatening way), so starting some fifteen months before the CBE centre was opened, the author arranged to give brief explanatory talks to groups of St. Anthony's teachers before the start of classes each evening. In order to accomplish this, some 15 or 20 minutes of class-time had to be sacrificed to enable the teachers to attend. The talks were supported by printed information brochures, which were intended to inform the teachers of the reasons for introducing CBE, to explain what it could accomplish and more important, what it could not accomplish.

The author tried particularly hard to ensure that the teachers should own the innovation and not feel that it had been imposed on them. He followed up with a series of demonstrations at existing PLATO sites, none of which unfortunately was closer than 40 kilometres to St. Anthony's.

The demonstrations were generally well received and some 50% of the total teaching force at St. Anthony's attended one or other session, which was regarded as satisfactory under the circumstances.

Some six months later, a single PLATO terminal was installed at St. Anthony's, using a dial-up facility and further demonstrations were provided each evening. These were less well supported because of the clash (again) with lessons, but the terminal was heavily used during the day by the full-time staff, who actually refused to allow Control Data engineers to remove it on schedule, so it stayed in use for a month instead of a week.

The last series of preliminary demonstrations to teachers came when the new CBE Centre at St. Anthony's was open. A number of teachers who were known to be interested in CBE and who taught subjects in which courseware was available, were invited initially to spend an entire evening working with the system and assessing the courseware offerings, while other teachers looked after their classes. This selective and rather intensive approach worked very well and a lot of interest was generated. All the teachers who came to those first exploratory sessions subsequently became PLATO enthusiasts and all made use of the Centre for their own classes.

The point that must be stressed here is that with the staffing structure that pertained, a teacher had to be a CBE enthusiast or he or she would simply not use the facility or not encourage the students to do so (15). With this knowledge, the evangelical zeal of the staff of the CBE Centre knew no bounds.

The disadvantages in respect of organising the most efficient use of the CBE Centre are, however, obvious.

The Students

St. Anthony's Adult Education Centre was used by adult students of all race groups (but predominately black) for evening study. Classes given ranged from literacy through the primary school courses to Standards 8 and 10 (10th and 12th grades).

It should be noted that a student who had passed Standard 6 (8th grade) could move directly to Standard 8 (10th grade), although he/she would usually take two years to complete all subjects for his examination. Similarly, once having passed Standard 8, he/she was allowed to register for Standard 10 (12th grade), again taking two years. A typical senior school student would probably be taking three subjects per year. He/she would attend classes in those subjects on three evenings a week, thus leaving one week-night free from classes. This gave him/her teacher contact time of between 60 and 80 hours per subject per year. A full-time student at a similar level would enjoy roughly 132 hours per subject per year for two years (264 hours total).

A different group of students used St. Anthony's on Saturday mornings. These were undergraduates, registered by correspondence with the University of South Africa (UNISA), who received tutorial assistance at St. Anthony's. In the case of some science subjects, the University did not provide any tuition for its students. It merely supplied a syllabus and acted as an examining body, so St. Anthony's arranged for qualified people to teach those students, using the UNISA syllabus as a guide.

The laboratories at St. Anthony's were among the very few accessible to part-time students that were accredited for use by the University and, students of all races from all over the Pretoria-Witwatersrand-Vereeniging conurbation attended classes and practicals.

St. Anthony's also ran courses for secretarial students, both full and part-time. Students were taught several subjects in addition to typing and the course seemed to be highly regarded in commerce as its graduates had no difficulty in finding employment.

The St. Anthony's complex was also used by various other people such as pupils from nearby schools, who purchased food and drink from the fast-food hatch or who whiled away free periods on the premises. Other youngsters attended catechism classes, practised karate and indulged in a wide variety of activities at St. Anthony's. These all formed the basis for a somewhat heterogeneous group with an interest in the CBE Centre that could perhaps be more accurately described as "users" than students.

Courseware

The PLATO catalogue contained several thousand hours' worth of lesson material in a hundred or more different subjects. Most was of U.S. origin.

A decision was taken very early in the life of the project to concentrate courseware offerings at St. Anthony's on a few subjects where student-needs had been established and where relevant courseware was available. Investigations revealed that the primary objective of almost all students was to pass their examinations and to obtain a recognised qualification. Thus it was decided that the primary objective of the CBE project had to be to assist them to achieve that ambition by supporting the work done by traditional means of teaching. Naturally, with a rigid syllabus controlling what students were taught for public examinations, any courseware offered had to be appropriate for the dictates of the syllabuses. This excluded a good deal of the U.S. source courseware as it was outside the syllabus or too strongly culturally biased.

A detailed analysis of courseware would be inappropriate in this paper, however, a brief consideration of a single example of cultural differences will illustrate the problems inherent in international courseware transfer. One of a series of lessons on English grammar dealt with "homonyms". A study of the lesson showed that what the authors of the lesson meant by "homonym" was what we in the English-speaking (as opposed to the American-speaking) world would have called a "homophone".

Fortunately, such examples are fairly easily spotted - and this particular one was modified locally - but their existence points to the need for careful selection of course: it would be unwise to allow students to have free access to anything in the catalogue that took their fancy.

Senior School Students

The greatest number of student-users of the system have been those in Standard 10 (12th grade) who took Mathematics, Physical Science and Biology, while some Standard 10 and Standard 8 English students have also used CBE.

At the start of the operational life of the project, little local CBE courseware was available, so various relevant lessons were selected and placed in a group (using the PLATO mrouter). This allowed students to have unrestricted access to any lesson from that group in a computer-assisted instruction (CAI) mode, which while being very useful, neglected the powerful PLATO Learning Management (PLM - the PLATO computer managed instruction) facilities that are such a valuable feature of the system.

During the course of the year, the Control Data Courseware Development Team made available some PLM material (16), first in Physical Science and then in Mathematics, which was used with alacrity by St. Anthony's students. No development activity was underway at the time in Biology and students continued to use the U.S. - source CAI lessons in that subject.

Basic Skills Curriculum (17)

The Basic Skills Curriculum was developed in USA. Its target population was early school-leavers and educationally disadvantaged adults who studied English Language, Reading and Mathematics. The lessons did not, of course, follow South African school syllabuses but there was a good deal of overlap in particular areas. The author considered that at the most elementary level the lessons were roughly equivalent to Standard 2 and about Standard 5 at the highest level (grade 4 to grade 7).

All lessons and tests in the Basic Skills Curriculum were modified locally for South African users.

The Basic Skills Curriculum as a whole included 450 hours of material. As an entity, it had limited use in an institution like St. Anthony's as it did not lead to a particular academic qualification such as Standard 5. There was sufficient flexibility though for students to take portions of it as required and it was a section of the language component of the curriculum that was taken by the first students to use the system at St. Anthony's. These were a group of 15 "coloured" school teachers who had gone back to studying for the Standard 10 Certificate (12th grade) but who were having difficulty with basic English language skills, being mother-tongue speakers of Afrikaans.

Since then, further groups of students from both Standards 8 and 10 have enrolled for parts of the Basic Skills English courses, not with a view to learning examination-specific material, but simply to improve the "basic skills" in the language that they were so sorely lacking. It will be interesting to follow the long-term progress of this group.

The fact that second-language users of English can reach Standard 10 level while being so deficient in basic English language skills, is a significant comment on the standards of language teaching that they experienced at school.

Some local school children also tackled parts of Basic Skills, mainly with a view to improving their school work. One lad, a dyslexic, was brought into the Centre by his sister who worked in the student canteen at St. Anthony's. He was probably the most regular user of the system and every day he would religiously spend an hour at the terminal. According to his headmaster, his school work - and his selfconfidence - improved greatly as he progressed with the course.

UNISA

The UNISA students attended classes on Saturdays and those taking Chemistry used the system quite extensively. A great deal of PLATO U.S.-source courseware was available for university science subjects and as cultural bias was not a factor at this level, the UNISA Chemistry I and II classes made regular and successful use of the CBE facilities.

Secretarial Students

The secretaries who were studying full-time in 1981, soon ranked among the most enthusiastic users of the CBE centre. Although CBE operations got under way during the last portion of their course, they adapted themselves readily to the new medium and used PLATO extensively to practise their typing.

Their teacher allowed them to do portions of the courses called "EXCEL" and "How to select and get a job", reasoning that these could assist the students, many of whom were moving from an educationally and culturally deprived background to the tough world of commerce and industry. She was pleased with the response of the students and planned to integrate CBE activities in her course in 1982.

Some of the administrative staff at St. Anthony's also used "EXCEL" during 1981 for personal development.

Usage of the Centre

There was an interesting occurrence concerning two UNISA students who went in each week from Pretoria on a Friday afternoon and spent the night in Boksburg, ready for class on Saturday.

They asked for access to the CBE centre on Friday evenings which seemed a reasonable request considering that availability outside normal class hours is a CBE feature. However, a human problem intervened: local people used the facilities on a Friday, not students. Someone was stabbed to death in the car park one Friday after a disco and the staff refused to open the CBE centre or to be present on campus at all on Friday evenings. Arrangements were eventually made for a key to be provided for the two students but the incident shattered the author's naive belief that if the system was available for eighteen hours a day, six days a week, people would use it for that length of time.

Another problem concerning usage of the CBE centre also manifested itself. The school term at the adult education centre ended

officially at the end of October 1981. Classes continued unofficially until 21 November 1981, after which all activity ceased until 18 January 1982. As most students were writing examinations in May and June of 1982, this was a vacation rather than an after-course holiday as it used to be when exams were written in November. The staff of the CBE centre naturally kept the centre open and made this widely known but apart from three students who went in on the second evening of the vacation, not a soul went near the place, thus leaving an expensive resource standing idle. A great deal of soul-searching and enquiry suggested that a number of factors were responsible. Firstly, students had transport problems as employers' transport was not organised during the vacation; for some reason or other the St. Anthony's security guards insisted on locking the place up tightly so that it looked as if nobody was there; and thirdly, pre-Christmas euphoria drove thought of study from students' minds. Possibly, there was also a conceptual gap as well: students had become so conditioned into thinking of group-mode learning that they may have had difficulty adjusting.

This remains a cause for concern for the project staff who have considered a variety of means to ensure more intensive usage of the centre during vacations.

Atmosphere in the CBE Centre

When the CBE centre was first opened, a selection of lessons was put together as a demonstration group with a multiple sign-on that enabled any user to enter the group on the same sign-on, without a password. Among the lessons were some of the excellent games that are found in the PLATO catalogue and it was not long before local children were swarming in to "play with the computer". For a while the staff were torn between their desire to see the demystification of alien technology proceed so well and their desire for order in the centre. Eventually the latter triumphed and an existing but previously unapplied rule that forbade any game playing had to be strictly enforced. The lesson that the staff learned was that the CBE centre had to be a learning centre: there was no room for a laissez-faire approach to discipline.

It is interesting to note, though, that without exception, students who were questioned in a survey conducted in November 1981, regarded the CBE centre as a pleasant place to study and without exception described the staff as helpful.

Individual instruction and multiple instruction

A most attractive feature of CAI was that it offered individualised instruction and the PLATO system's versatile and sophisticated learning management capabilities seemed to offer numerous additional advantages to adult students.

The compiler of the project plan confidently expected to see only a single student using each PLATO terminal. Instead, there was a tendency for students to work together at the terminals in twos or even threes. Not all did so: the secretaries who practised typing worked individually of course, as did the senior-school students who appeared to be most capable. It was remarkable, however, that numerous ordinary students seemed to prefer sharing, probably because of the security of having someone else nearby.

One of the early reasons for allowing the sharing of terminals was that whole class groups were taken into the CBE centre together to be introduced to the system and they had to double up as there were insufficient terminals. It was later noticed that, for example, students A and B who had started off together on A's sign-on, stayed together subsequently and even if B went in alone, he still used A's sign-on. That habit played havoc with on-line student records: one such man who was observed to be a regular user of the system was discovered to have never used the sign-on that had been allocated to him.

After the first seven weeks, teachers stopped taking whole class groups into the centre and a new pattern of usage became evident. Students started using the centre before classtime, arriving at say 18h00 and working hard until 19h00, when classes began. They would also go in to work on their "free" evenings. This was regarded as a more mature usage-pattern, indicating, it was felt, an ease with the technology that did not require the security of the presence of the rest of the class.

Not long before the new pattern emerged, there was one heady night when a class that had been taken into the centre by its teacher, refused to leave when asked to do so and spent the entire lesson working at the terminals.

In one respect, the usage-pattern confounded expectations. With the PLATO system functional until midnight, it was assumed that some students would wish to work in the CBE centre after the close of classes at about 20h30. During the entire six months of operations, not a soul ever stayed on after 20h45. This was ascribed to transport difficulties: most students had an hour or more of travelling time before reaching home, so it was not surprising that they moved off smartly.

Group-pacing

Group-pacing in CAI mode was used for the matric biology class when both teachers were away in November writing university exams. The students were given a list of a dozen or so CAI lessons that they worked through during the normal class time. This proved very successful although the absence in the Centre of people with specialist subject knowledge caused occasional problems.

It was found that most students preferred to have a subject-matter expert present in the CBE centre to ask for help, if required.

Student responses to CBE

Generally it was found that the students responded well to the terminals and did not seem to have difficulty in operating them. At first, some forgot their passwords, which the staff would then reset or switch off, but that was seldom necessary. Regular users had no trouble interacting with the system and entered mathematical symbols or Greek alphabet characters with aplomb. In fact, the amount of enthusiasm for the system was quite remarkable. The author decided that a combination of the power of the Church allied to the marvels of modern computers made for a learning system that, in the eyes of the students, could not fail them.

Technical reliability

Both hardware and software were generally reliable and there were remarkably few teething problems at the start of the project, except for an early tendency for the entire system to go down on Saturday mornings - a busy time at St. Anthony's.

Any persistent technical faults have a profound effect on a project that uses educational technology. An innovation has not only to work but to be seen to work: any user scepticism - and there is always some - will be exacerbated by any faults that emerge. Thus, the matter of greatest concern - more even than the down-time - is the psychological effect of a fault on participants whose attitude to the innovation can easily be clouded. Especially when those who participate do so voluntarily, their confidence in the system has to be maintained at top level. Thus, the most trivial fault takes on a significance to the project far beyond that of mere technical irritation.

Conclusions

The first six months at St. Anthony's passed in a reasonably satisfactory manner. The project began before the courseware that had been specially tailored for local needs became available and even in 1982, there was always a demand for CBE courses in subjects in which little or no appropriate courseware was available. Nevertheless, even with 16 terminals, the Centre was crowded out night after night during peak-usage hours with students using existing courseware, which suggests that more than enough was involved in meeting their needs without trying to cater for everybody.

Secondly, whilst it was felt that a reasonably good job had been done selling the innovation to the teachers (and the students), time remained the worst enemy. There never seemed to be sufficient time for teachers to become as thoroughly au fait with the intricacies of the system and the courseware as would have been desirable. Students too seemed to have to cram their learning into a few hours in the evening when terminal-usage was at peak, while the system was under-utilised at other times.

Probably the most vital lesson that was learned was that CBE should never be regarded as being in competition with traditional teaching for the student's limited time. With teacher-contact time so unbelievably restricted, every minute became precious and CBE should never encroach on that.

Once that was understood, CBE could be given its rightful place in the St. Anthony's centre : as a supplement to traditional teaching, available at almost any time to provide impartial teaching, testing and educational management of a consistently high standard so as to truly meet the actual individual needs of the students. To that end, the first six months of the project were, in the opinion of the author, successful.

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THE COMPUTER IN MULTIPLE CHOICE TECHNIQUES: METHODS AND REQUIREMENTS

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ABSTRACT

The computer is indispensable when multiple choice techniques are used because items have to be analysed.

Pre-punched cards are often chosen in preference to the various other input methods. A variety of processing methods and kinds of data on items, like the relationship between degree of difficulty and ability to discriminate between items, ideal distribution of responses over the alternatives, correction for guesswork and stability of data items are discussed.

The computer may also be useful for individual testing and cafeteria systems. Access to computer facilities (or service bureaux) for users of multiple choice techniques is regarded as indispensable.

DIE REKENAAR EN MULTI-KEUSE TEGNIEKE:

METODES EN VEREISTES

Objektiewe tegnieke van meting en evaluering word toenemend in onderrigssituasies toegepas. Tot redelik onlangs was navorsing hieroor en gebruik van ontledings-tegnieke beperk tot kundiges in die gebiede van Opvoedkundige Meting en Psigometrika. Namate toetse egter opgestel en evalueer word vir beperkte gebruik in klas-kamers en opleidingslokale het dit al meer nodig geword dat kennis van toets-opstelling, maatstawwe van toetsgeldigheid, itemontleding en ander tegniese aspekte wyer beskikbaar moet wees.

IS 'n REKENAAR WERKLIK NODIG?

Omdat objektiewe tegnieke maklik geoutomatiseer kan word, word rekenaars dikwels gebruik om antwoorde na te sien, puntestate uit te druk ensovoorts. Die tydbesparing hieraan verbonde is egter minimaal. In een situasie is bevind dat vir 'n groep van sowat 20^o studente wat 'n 50-vraag multikeusevraestel gedoen het, die handnasien met 'n masker en skryf van punte op 'n klaslys sowat 3,5 uur geduur het. Die voorbereiding van beheerkaarte, invoer, ontfouting, rekenaarverwerking en wag vir uitdrukke neem vir dieselfde groep studente normaalweg ook 3 tot 5 uur. Gebruik van die rekenaar vir slegs die nasien is dus onekonomies.

Wanneer die volle item-ontleding met die hand egter gedoen word neem dit sowat 100 uur (en heelwat foute word begaan weens die herhalende en vervelige soort werk). Met die huidige beskikbare rekenaar-pakette neem die item-ontledings slegs enkele sekondes en die ekstra kostes is minimaal. Die werklike besparings is dus in die analise-gedeelte.

Ten spyte van goeie bedoelings deur die opsteller van toetsitems toon analyses dat items nie noodwendig goed is as dit deur 'n kundige opgestel is nie. In enkele gevalle is tot so min as 15% van items in 'n werklike toets ná ontleding as nuttig aangedui.

Probleme met die gebruik van 'n rekenaar sentreer meestal rondom die metodes van invoer, die verwerking en die soort inligting wat verkry word.

INVOERMETODES

In elke stelsel moet besluit word oor die invoertegnieke. Waar individuele toetsborde ("keyboards") of terminale beskikbaar is, verskaf dit die mees direkte interaksie met die verwerkingseenheid. Andersins is basies 3 metodes beskikbaar:

Optiese Antwoordvelle: Studente merk antwoorde met 'n potlood op 'n vel wat dan in 'n optiese merklezer of direk gelees word, of op ponskaarte oorgeplaas word. Die belangrikste voordele hiervan is dat 'n groot aantal vrae op een bladsy beantwoord kan word en verder dat veranderinge maklik gedoen kan word deur uit te vee. Die

belangrikste nadeel is die afhanklikheid van 'n spesiale soort apparaat en antwoorde-
velle wat akkuraat gedruk moet wees. Indien die nasienapparaat sensitief is vir
potloodmerkies en kreukels in die papier kan tot 30% uitskot verwag word.

Gewone antwoordvelle: Antwoorde kan op 'n afgerolde antwoordvel gemerk word waarna dit op die gewone wyse gepons en verwerk word. Mits die antwoordvelle goed ingevul is het hierdie tegniek waarskynlik die minste uitskot. Die belangrikste nadeel is sekerlik die ponsfasiliteite wat nie oral beskikbaar is nie en die lang wagtyd in besige periodes. Studente wantrou ook soms die vermoë van die tussenkomende persoon om die response akkuraat te pons.

Voorafgeperforeerde kaart: Kaarte word gebruik waarop gaatjies reeds vooraf geperforeer is sodat die studentenommer, antwoorde en enige ander inligting verskaf kan word deur 'n blokkie volledig uit te pons.

[illegible]

Sommige voordele is dat direk met die student se respons gewerk word en dat verwerking dus kort na die toets gedoen kan word. Van die nadele is dat as veranderinge gedoen moet word nadat die gate reeds gepons is, die hele kaart oorgepons moet word. Verder pons studente ook nie altyd goed nie, sodat blokkies loshang. Sommige kaartlesers is meer sensifief as ander en uitskot kom voor.

Ten spyte van hierdie probleme word hierdie tegniek tog deur baie dosente verkies. Foute met ponswerk, verkeerde studentenummers, dubbele antwoorde ensovoorts word grootliks bepaal deur die ervaring van die studente en die opleiding en instruksies. In een geval was dit aanvanklik 8 tot 10%, wat met die derde toets afneem het na 3 tot 5%. Hierdie uitskot beïnvloed nie die item-ontledings nie en kan maklik geïdentifiseer en met die hand nagesien word.

VERWERKINGSMETODES EN AFVOER:

Tevore is reeds genoem dat hoewel die rekenaar nie juis besparing meebring by die nasien van antwoorde nie dit noodsaaklik is by die ontleding van itemdata.

In die vakgebied Psigometrika word die eienskappe van toetse en toetskonstruksie volledig bestudeer. Uiteraard kan alles nie hier gedek word nie. Volgens drie van die mees bekende navorsers en skrywers in hierdie gebied is die volgende inligting nodig om te kan besluit of 'n item (of vraag) geskik is vir gebruik met 'n bepaalde groep: (Ghiselli, Campbell & Zedeck, 1981):

- Kennis oor die doel van die toets en toetsitems
- Kennis oor die eienskappe van die toetsitems:

Item-moeilikhedsgraad (% studente wat item korrek het)

Item-homogeniteit (item-interkorrelasie)

Item-geldigheid (diskriminasie - vermoë van item om te onderskei tussen beter studente en swakke studente)

Eienskappe van die afleiers (% studente wat elke afleier gekies het)

Benewens hierdie maatstawwe is verskeie ander verwerkings ook nuttig.

- Ontfouting - aanduiding van foute op kaarte of met biografiese inligting.
- "Weging" of besparing van afdelings, items of alternatiewe
- Korreksie vir raaiwerk
- Kombinerings van verskillende afdelings
- Druk van klaslyste en data oor prestasies soos verspreiding, klasgemiddelde, standaardafwykings ensovoorts.

Om besluitneming oor die kwaliteit van die items en die meting van die klas te vergemaklik moet ál bogenoemde verwerkings gedoen word. Verskillende programme sal dit uiteraard op verskillende wyses doen. Daar is egter enkele gebiede waaroor daar verskillende standpunte bestaan. Hoewel die psigometrie argumente nie hier behandel word kan die volgende gestel word:

1. Items onderskei die beste wanneer die moeilikhedsgraad naby aan ,50 is. Hoe moeiliker of makliker die item, hoe laer is die diskriminasievermoë. Maklike items, veral aan die begin van 'n toets is egter noodsaaklik veral weens die

motiverende waarde daarvan. Moeilike items moet ook ingesluit word om as uitdaging vir die beste studente te dien.

2. Die ideaal in terme van 1 studente wat die korrekte antwoord en die alternatiewe kies, is

	<u>A*</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
Beste groep:	100	0	0	0	0
Swakste groep:	20	20	20	20	20

Die moeilikheidsgraad is in hierdie geval ,60.

3. Item-weging sowel as alternatief-weging verhoog nie die betroubaarheid en geldigheid van die toets nie (Ghiselli, et al, 1981). Onwillekeurige weging vind ook soms plaas, wanneer twee of meer afdelings waarvan die variansies verskil, bymekaargetel word.
4. Korreksie vir raaiwerk lyk intuïtief noodsaaklik, maar empiries maak dit weinig verskil tussen die volgorde van prestasies as alle studente alle items moet beantwoord. Indien die toets-instruksies egter raaiwerk verbied of ontmoedig het dit moontlik die volgende gevolge:
- Hoër spanning by toetslinge
 - Individuele verskille in neiging tot raaiwerk
 - Penaliserings van "werklike" foute
- Korreksie word aanbeveel slegs in gevalle van spoedtoetse en waar-onwaar items (Atkins, 1974).
5. In teenstelling met aanlegtoetse verander die itemdata van akademiese prestasietoetse weens onder andere spesifieke kursusinhoude (Voorbeelde word aangebied). Inligting oor items is dus slegs beskikbaar nadat die toets reeds geskryf is. Ervaring en noukeurige navolging van voorskrifte insake skryf van multi-keuse-items is dus baie belangrik.

TOEKOMSTIGE GEBRUIK VAN REKENAARS IN MULTIKEUSETOETSING:

Wanneer itembanke in rekensargeheues "gestoor" word kan dit op verskeie wyses gebruik word:

Individuele toetsing ("Tailored Testing"):

Gewoonlik moet alle studente alle items beantwoord. Dit is moontlik om fyner te onderskei tussen studente deur elkeen sy eie pad van items te laat volg. Die student begin met in item van gemiddelde moeilikheidsgraad en as hy dit korrek het word 'n effens moeiliker item aan hom voorgelê. As hy dit verkeerd het weer 'n makliker een, ensovoorts.

Voordele hiervan (volgens Ghiselli et.al., 1981) is:

- Besparing in toetstyd

- Vermindering van frustrasie a.g.v. té maklike en té moeilike items
- Beter geldigheid en betroubaarheid

Sommige nadele is:

- Foutiewe aanduidings aan die begin van 'n toets
- Itemdata bly nie heeltemal stabiel in prestasie-toetse nie.

Kafeteria-stelsel:

Indien genoeg items in die toetsbank beskikbaar is kan 'n sg. kafeteriastelsel gebruik word.

Die kursus word in modules verdeel en verskeie tegnieke word gebruik vir selfstudie. Namate studente meen dat die eenheid bemeester is word 'n sentrale kantoor besoek waar 'n toets oor daardie module aangevra word.

Vir elke student word 'n individuele toets met dieselfde moeilikheidsgraad en dekkingsgebied, maar met verskillende items, uitgedruk. Indien die vereisde standaard bereik word, word die volgende module bestudeer. As die vereisde standaard nie bereik word nie word die module weer bestudeer en weer 'n toets aangevra.

Hoewel dit nog nie duidelik is of so 'n sisteem beduidend beter resultate lewer nie, is dit 'n nuttige variasie op die gewone lesing-metode.

GEVOLGTREKKING:

Hoewel dit moontlik is om multi-keuse tegnieke in die onderwys te gebruik sonder die rekenaar, sal dit steeds 'n skoot in die donker bly. Elke gebruiker behoort dus geredelike toegang tot in 'n rekenaar te hê en kundiges behoort beskikbaar te wees om te help met verwerking en interpretasie van die itemdata. Wie hierdie diens sal moet verskaf, of dit sentrale diensburo's moet wees en waar dit gesetel kan word is moontlik nuttige besprekingspunte vir hierdie konferensie.

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THE COMPUTER AND MULTIPLE CHOICE TESTING:

METHODS AND TECHNIQUES

(Brief version)

Knowledge of the technical aspects of objective techniques and test theory can no longer be limited to specialists in psychometrics. Tests are compiled and analysed in many specific situations.

ARE COMPUTERS REALLY NECESSARY?

When computers are used to grade papers the time-saving over manual techniques is minimal. In one specific situation the author graded 50 questions for 200 students manually in about 3,5 hours, whereas the time spent on computer grading is normally 3 to 5 hours.

But manual item-analysis took about 100 hours as opposed to a few seconds extra for computer analysis.

The fact that test-items are written by knowledgeable teacher unfortunately does not ensure its quality. In one case the author found only 151 of items in an actual test to be of acceptable quality.

INPUT:

Aside from direct interactive techniques basically 3 input mediums can be used

Optically-read answer sheets

Answer sheets (punched afterwards)

Prepunched cards

[illegible]

Although the prepunched cards do give problems, it seems to be most often chosen by teachers. Students tend to be careless in punching, but this can be improved by practice and specific instructions.

COMPUTATION AND OUTPUT

In order to decide on the quality of items the following information is needed (Chiselli, Campbell & Zedeck, 1981):

- Objectives of the test and test items
- Difficulty of items
- Item-homogeneity
- Item validity
- Performance of distractors

Several other computations could be useful:

- Eliminating errors
- Weighting of items or alternatives
- Correction for guessing
- Combined scores for sections
- Printing of lists and descriptive statistics of class performance

Although all facets cannot be covered here some problem areas can be noted:

1. Item difficulty and discrimination has a curvilinear relationship.
2. The ideal spread of responses is

	<u>A*</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
Top 25%	100	0	0	0	0
Bottom 25%	20	20	20	20	20

3. Item and alternative weighting contribute insignificantly to test reliability and validity.
4. Correcting for guessing should only be applied when test instructions forbid guessing. However this contributes to:
 - Higher anxiety
 - Individual differences in tendency to guess
 - Penalising of genuine errors (Atkins, 1974).
5. Item data changes depending upon specific contents of the course and lectures. (Some actual examples are presented.)

FUTURE USE OF COMPUTERS IN MULTIPLE CHOICE:

Tailored testing

Cafeteria systems in mastery learning

In conclusion, expertise and hardware should be available to all users of objective tests. Where, how and which services, could possibly be discussed.

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TEACHING STRUCTURED PROGRAMMING PRINCIPLES

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ABSTRACT

This paper starts off by discussing the fundamental principles of structured program design and their implementation in programming languages. It attempts to underscore the pedagogic importance of sound programming practice from the moment the student is first taught to program. Most teachers have to rely on BASIC in introductory programming courses. A version of BASIC, known as Waterloo BASIC, is shown to provide the language constructs needed to teach structured programming.

1. INTRODUCTION

It is well established that there are certain principles which must be applied when writing a computer program which is easy to read and maintain. These programming principles are generally known as **structured programming**.

Edsger Dijkstra may well be considered as the first computer scientist to recognise the advantage of structured programming. In 1965 he suggested at the IFIP Congress [DIJK65] that the instruction GOTO, common in most programming languages at that time, could be eliminated. Despite the fact that the Congress was widely attended by an international audience, his suggestion went mainly unnoticed. In March 1968 Dijkstra repeated his ideas in a letter to the editor of the Communications of the ACM [DIJK68], in a now famous letter titled "GO TO statement considered harmful".

Today, more than a decade later, computer programming languages are designed with the principles of structured programming in mind. Moreover, structured programming is firmly entrenched in the basic principles of computer program design.

2. Top-down Program Design

In this scheme, an entire program (or system) is considered first as an independent "callable" module (and indeed, it often works out that way -- any application program is often called as a subroutine by the operating system, and it returns to the operating system when it completes or aborts). At the next stage of design, the original (level 0) program is broken into subordinate "level 1" modules; these are then decomposed into level 2 "sub"-modules; and the decomposition process continues until the designer is left with building blocks that are small enough to code easily.

Böhm and Jacopini [BÖHM65] have shown that such a top-down structure can be composed using a language with only two basic branching structures - the implementation of which is a function of the programming language used.

The two basic elements needed are the **process box** and the **binary decision box** shown in the following diagrammes:

The Process Box

Figure 2.1

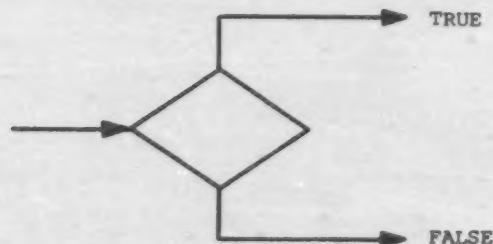
The Binary Decision Box

Figure 2.2

The process box may be thought of as a single computational statement (or machine language instruction) or as any other proper computational sequence with only one entry and one exit - such as a subroutine.

The results of Böhm and Jacopini show that any arbitrary program can be constructed from the following two constructs which in turn are constructed from these two boxes: a looping operation indicated as follows:

The Simple Looping Construct

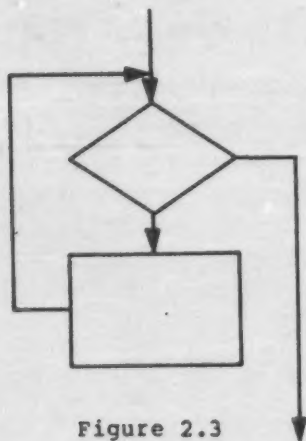


Figure 2.3

and an **IF-THEN-ELSE** construct illustrated by the following diagram:

The IF-THEN-ELSE Construct

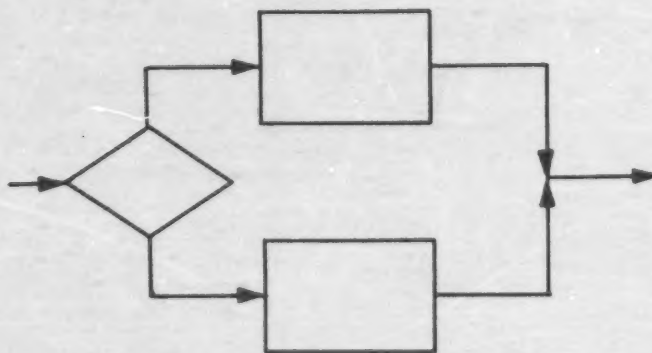


Figure 2.4

Note that each of the constructs shown in figures 2.3 and 2.4 respectively can themselves be taught of as a **process box** since they have only one entry and one exit. Thus a transformation from a **looping operation** to a process box as shown in figure 2.5 can be defined and thereafter any such looping operation can be considered as being equivalent to a (slightly complex) process box:

Transformation of a looping construct to a process box

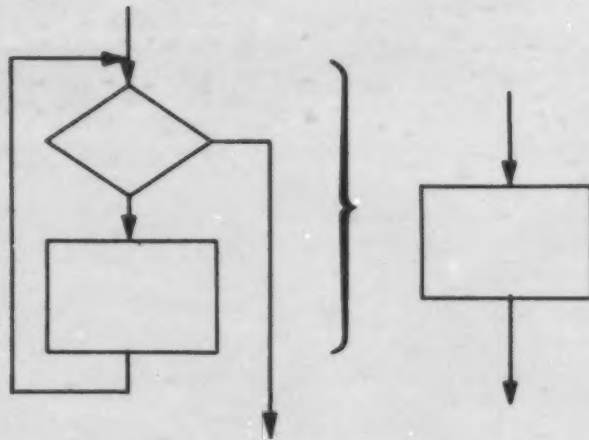


Figure 2.5

Similarly, a transformation from the decision box to a process box can be defined:

Transformation of the IF-THEN-ELSE construct to a process box

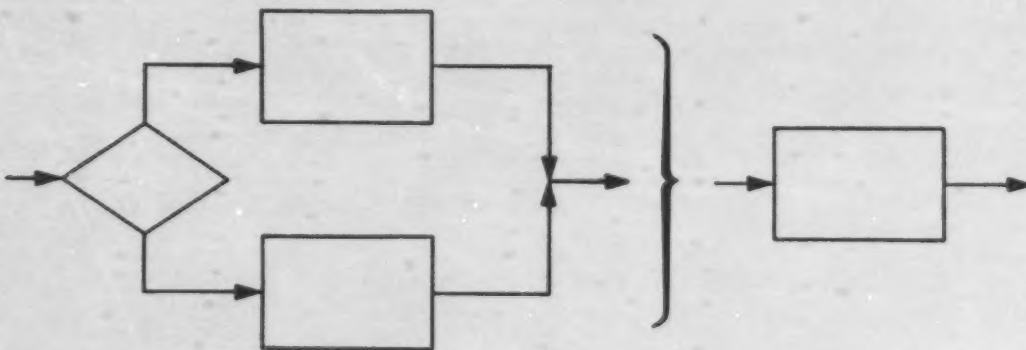


Figure 2.6

Finally, any linear sequence of process boxes can be transformed into a single process box as follows:

Transformation of a Series of Linear Process Boxes to a Single Process Box

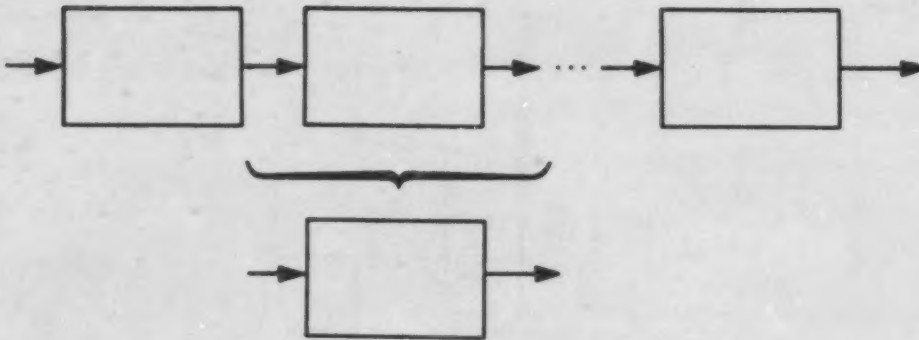


Figure 2.7

Any program that is composed of process boxes, looping operations and IF-THEN-ELSE constructs can thus be transformed through the use of the succession of transforms illustrated in figures 2.5 through 2.6, to a single process box. This sequence of transformations may then be used as a guide to understanding the program designed in this way.

3. Structured Programming and Programming Languages

The theoretical basis of structured programming lends itself to implementation in many of the current programming languages. The principles are quite simple: All processing in the program must consist of straight line statements (e.g., ordinary computational statements), or one of the following three control statements:

1. Procedure calls, subroutine calls, function invocations -any legal call to a closed subroutine with one entry and one exit.
2. IF-THEN-ELSE statements, nested to any depth.
3. Some looping construct. The most common suggestion is the DO...WHILE construct in ALGOL.

These three principles are essential in the design of any computer program and it is essential that a student should be taught these principles from the start in order to make him accustomed to well-written software.

4. Pedagogic Consideration

Teaching structured programming at an elementary level, is a nearly impossible task without a suitable simple implementation language such as BASIC extended to include the necessary language structures. The availability of these structures allows the student to carry his disciplined techniques through to the coding and debugging of his program in a straightforward and uncomplicated manner. Without these structures, much of the motivation for the application of systematic programming methods is lost, because the result of the effort is not reflected in the final product. In fact, the final product is often more difficult to achieve for the beginner programmer. At some point in the development of his algorithm, he is forced to switch from a more natural environment of algorithm description (using meaningful terms of control logic such as IF-THEN and DO-WHILE), to the realm of the GOTO and labels. Condition complements are often required, and labels and explicit transfers must be inserted into the algorithm. For the student and indeed for many of us, this switch is rather difficult. The additional implementation effort quickly convinces the student that the disciplined approach is of little use, and it is soon abandoned.

The conclusion to be reached from the above is that teaching disciplined programming in a normal student environment using only Standard BASIC is counterproductive. Some basic extensions to the language are essential in order to provide an environment in which the result of a student's disciplined efforts can be demonstrated in the final product, the program.

In the remainder of this paper, a set of basic control structures is described that have been added to BASIC in order to provide a more natural environment for teaching elementary programming, typically at high school introductory computer science course level.

5. Structured BASIC

The language described in this section was developed at the University of Waterloo in Canada [GRAH80] and is known as Waterloo BASIC for the Commodore PET computer.

Provision is made in the language for the process box, the binary decision box, the simple looping construct as well as the IF-THEN-ELSE construct.

5.1. The Process Box

One of the basic principles of structured programming is that of allowing statements in a programming language to consist of either a straight-line statement or a collection of statements with a single entry point and a single exit point.

Waterloo BASIC allows for the latter construct through the use of a

combination of the **PROC** and **ENDPROC** statements as well as the **CALL** statement.

The **PROC** statement specifies the beginning of a block of statements to be executed when an appropriate **CALL** statement is encountered in the program. This **CALL** statement will reference the "procedure-name" defined in the **PROC** statement and the end of the block of statements is specified by the **ENDPROC** statement. The procedure name may be composed of an arbitrary number of characters.

When the **CALL** procedure-name statement is executed, the flow of program execution is transferred to the procedure with the specified "procedure-name". This procedure is defined by the **PROC** and **ENDPROC** statements. After the statements in the procedure are executed, control returns to the statement following the **CALL** statement.

5.2. The Simple Looping Construct

This construct is provided for in Waterloo BASIC by the **LOOP** statement and the **WHILE** statement.

The **LOOP** statement specifies the beginning of a block of statements to be executed repeatedly. The end of the block is specified by an **ENDLOOP** or **UNTIL** statement.

The syntax of the **UNTIL** statement is

UNTIL condition

This statement specifies the end of a block of statements to be repeatedly executed. The beginning of the block of statements is specified by the **LOOP** or **WHILE** statements. The specified "condition" is evaluated after the enclosed block of statements is executed once. If the condition is found to be false, control returns to the beginning **LOOP** or **WHILE**. If the condition is found to be true, execution continues at the statement following the **UNTIL**.

A similar simple looping construct may be built up with the use of the **WHILE** and **ENDLOOP** or **UNTIL** statements. The **WHILE** statement has the following syntax:

WHILE condition

This statement specifies the beginning of a block of statements to be repeatedly executed. The end of the block of statements is specified by the **ENDLOOP** or **UNTIL** statements. The specified "condition" is evaluated before the enclosed block of statements is executed. If the condition is found to be true, the enclosed block of statements

is executed, then control returns to the WHILE where the condition is evaluated again. If the condition is found to be false, execution continues at the statement after the **ENDLOOP** or **UNTIL**.

5.3. The IF-THEN-ELSE Construct

Waterloo BASIC provides five different statements which in various combinations allow this construct to be built up. The first such statement is the **IF** statement with syntax

IF condition

This statement specifies the beginning of a block of statements whose execution depends on some condition or conditions. The end of the block is specified by the **ENDIF** statement. When executed, the "condition" is evaluated. If it is found to be true, execution continues with the following statement, and proceeds until a corresponding **ELSEIF**, **ELSE** or **ENDIF** is encountered. Control then transfers to the first statement following the corresponding **ENDIF**. If the condition is found to be false, control is transferred to the first corresponding **ELSEIF**, **ELSE** or **ENDIF**.

The **ENDIF** statement thus specifies the end of a block of statements whose execution depends on some condition or conditions. The beginning of the block and the first condition are specified by the **IF** statement.

The third statement in the collection of statements which may be used to build up the **IF-THEN-ELSE** construct is the **ELSE** statement. This statement must be used in conjunction with the **IF** and **ENDIF** statements. It specifies the beginning of a block of statements to be executed when all previous corresponding **IF** or **ELSEIF** conditions were found to be false. Execution continues to the corresponding **ENDIF** statement.

A statement which may be used in conjunction with the **IF** and **ENDIF** statement to achieve an **IF-THEN-ELSE** construct is the **ELSEIF** statement which has the following syntax

ELSEIF condition

If all previous corresponding **IF** or **ELSEIF** conditions were found to be false, the specified "condition" is evaluated. If it is found to be true, execution continues with the next statement and proceeds until a corresponding **ELSEIF**, **ELSE** or **ENDIF** is encountered. Control then transfers to the first statement following the corresponding **ENDIF**. If the condition is found to be false, control is transferred to the next corresponding **ELSEIF**, **ELSE** or **ENDIF**.

Finally, a statement which allows a transfer out of a simple loop or

an **IF-THEN-ELSE** construct while preserving the basic structured programming principle of single entry and a single exit point is the following statement:

IF condition THEN QUIT

This statement must occur within the block of statements defined by **LOOP** and **ENDLOOP**, **WHILE** and **ENDLOOP**, **LOOP** and **UNTIL**, **WHILE** and **UNTIL**, or **IF** and **ENDIF**. When encountered, the specified condition is evaluated. If it is found to be true, control is transferred to the statement following the block of statements; that is, the statement following the **ENDLOOP**, **UNTIL** or **ENDIF**.

6. Conclusion

Given a specific algorithm, there is no such thing as a single unique computer program which implements the algorithm in a particular programming language. This fact tends to deceive most computer programmers in that the impression is created that the only measure of success is whether a program "works". Unfortunately many teachers of computer programming are also under this false impression.

There are in fact other considerations in deciding whether or not a computer program is good or not. These are generally known as structured programming principles. Whilst enumerating these principles, it is shown that for the teacher who has to rely on BASIC for teaching introductory programming principles, a version of this language is available which allows the teacher to adhere to these sound principles. In this way, the teacher can provide his students with a solid foundation on which to build their programming skills. The language is known as Waterloo BASIC.

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THE EFFECT OF IMMEDIATE FEEDBACK ON ACHIEVEMENT IN TELEVISED STATISTICS

LECTURES

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ABSTRACT

A televised course in mathematics and statistics has been developed over a four year period, from 1978-1981. During this period, a Cybercom computer system was used to analyse the effectiveness of the televised lectures. This paper describes the results of an experiment which was conducted in an attempt to determine the effect on learner achievement of immediate feedback during the televised lectures. An outline of the structure of the Cybercom system and the televised lectures is given and a brief review of educational research into the effects of immediate feedback is presented.

INTRODUCTION

The main purpose of this paper is to discuss an investigation into the effect on achievement of feedback provided by an educational computer system to university students while they are viewing televised statistics lectures. In order to provide the background for this discussion, three essential elements of the investigation must first be described : the nature of the televised lectures, the educational computer system and research findings on the effectiveness of feedback.

TELEVISED STATISTICS LECTURES

The televised lectures, which have a unique structure, form part of a teaching strategy which is being developed for service course teaching in statistics at the University of the Witwatersrand. Only the important characteristics of the televised lectures will be described, as a detailed account of their structure and development is available [1].

The motivation behind the introduction of televised lectures was twofold : first, as large numbers of students are taking an introductory course in statistics where only a limited number of lecturers are available, the televised lectures were seen as a means of replacing the lecturer in large lecture theatres and allowing for more personal instruction between lecturer and student in smaller tutorial groups. Secondly, the televised lectures are available for close scrutiny and evaluation and therefore their instructional quality can be improved by removing or changing ineffective parts of the lectures [2].

The format of the lectures consists of alternating between the traditional talk and chalk type lecture and television graphics. It was found that students reacted favourably to intermittent appearances of the lecturer in his familiar surroundings as opposed to a lecture consisting entirely of television graphics. The inclusion of the graphics was prompted by the obvious advantages of the televised medium. Animations, or close-ups can be used which is not usually possible in a live lecture. The graphics were however kept relatively simply and large production costs and resources were minimized. This decision was influenced by Ksobiech [3] who, while admitting that there are some opponents to the view, claims that there is no conclusive evidence to indicate that dynamic production techniques (such as animation, colour, special effects, etcetera) increase the amount of information gained by students.

One dynamic production technique however, plays an important role in the lectures. A colour coding system is used to indicate to the students what activity they should be engaged in at any point. If they are expected to passively watch the lecture, graphics with a blue background are used. This means that, at best, the students can only be involved in responding covertly to the lecture. Covert responding usually refers to 'thinking' the answer or

just reading while overt responding involves writing answers or selecting from multiple choice alternatives. In certain sequences there is no time for students to react overtly and Levie and Dickie [4] state that covert responding is better at fast presentation rates which will not allow time for overt responses. It was found however that extensive use of blue backgrounds resulted in failures of attention. Attention, as it is referred to here, is generally conceived of as an activity which must occur before a stimulus will be associated with a response [5]. In an attempt to reduce the number of attention failures, lecture sequences were introduced where the students should respond overtly. Thus in order to indicate to the students when overt responding is necessary, another two background colours are used with the graphics.

A green background is used when students are expected to actively make notes on the lecture and a slight slowing of the pace of the lecture occurs. This coloured background includes any notes which the lecturer might make on the green chalkboard. The green background acts as an 'attention getter' and when it was first introduced, the frequency with which 'failures of attention' occurred, dropped dramatically. A second type of overt response is elicited from the students in the form of a question which is based on the preceeding teaching sequence. A brown background is used when the question is displayed.

The introduction of the questions was initially intended to enable the lecturing staff to evaluate the instructional effectiveness of the lectures. In order to evaluate the televised lectures, a criterion referenced approach to instruction was adopted which is based on learner achievement of behaviourally stated objectives [6]. The specific abilities which students should achieve at various stages during the lecture are described in terms of observable student behaviour. In other words, what should the students learn from each instructional sequence in the lecture, and how will they demonstrate this achievement? A very simple or basic question is generated which tests the achievement of this ability. The question is inserted into the television lecture at the end of the relevant instructional sequence and displayed for a fixed period of time. By using this method of evaluation, an accurate measurement of the lecture's instructional effectiveness in terms of learner achievement is obtained and it is also possible to improve the effectiveness of the weak areas in the lecture [2].

It was found that the questions, besides their evaluative function, contribute to the lecture in other ways. They act as 'attention getters' and, as was the case with the green background graphics, they lower the frequency with which 'failures of attention' occur. It was also found that the mere insertion of the questions appears to improve the effectiveness of the lecture. This could be explained by their ability to generate 'mathemagenic behaviour'

[7] - a term which is used to describe attending behaviours that give birth to learning. It has been found that test-like questions presented before or after the material to be learnt are mathemagenic [8].

Another result of the introduction of the questions is that they present the possibility of providing the students with feedback after they have answered the questions. The answers to the questions appear at the end of the lecture, thus providing students with delayed feedback. It is this aspect of the televised lectures which led to the present study. When evaluating the effectiveness of the lectures, the students' responses are recorded immediately via an educational computer system. This computer system also allows for immediate feedback regarding the nature of the responses to be given to the students. Thus the question arose as to whether or not achievement ratings would improve if the students were given immediate feedback via the computer system. In order to explain how the responses are recorded and the form in which the feedback is given, a brief description of the computer system employed must follow.

A final note regarding the colour coding in the lectures can be made at this point. The colours which were chosen to indicate the various activities which the students should engage in were given careful consideration. Research has been conducted on background colours in an attempt to establish the effect these colours have on visual acuity [9]. This research revealed no simple conclusions as visual acuity appears to be related to the luminance and transmission of the colour concerned. As the findings are not sufficiently conclusive, the recommendations were not adhered to for the selection of a background colour. A far more pragmatic attitude has been adopted. When reproducing copies of video tapes, there is a resultant loss of quality with each generation. Certain colours deteriorate in quality more rapidly than others. For example, red becomes very 'scratchy' as one goes from a second to a third generation tape with the equipment which is presently used. Therefore, background colours were chosen which give a lower 'deterioration of quality' rate.

CYBERCOM COMPUTER SYSTEM

This educational computer system has been developed in South Africa over the past few years. The system's full name is the Cybercom Multimode Education Communication System and is usually referred to as the Cybercom system [10]. As the name indicates it can operate in a variety of modes so as to satisfy the various needs of different teaching/learning conditions and techniques.

Individual computer access is available to each student and the teacher in a classroom/lecture theatre situation. Each student is supplied with a relatively small and simplified keyboard or student panel which (besides incorporating a standard type of keyboard) has a small window which displays a certain number of digits/letters at any one time, not dissimilar to an electronic calculator. The

instructor has a more sophisticated keyboard and video display unit and it is via these components that the instructor and students achieve communication with a mini-computer and each other. The relationship between these components is indicated in figure 1. A printer and disk unit are other hardware items which can be used with the system.

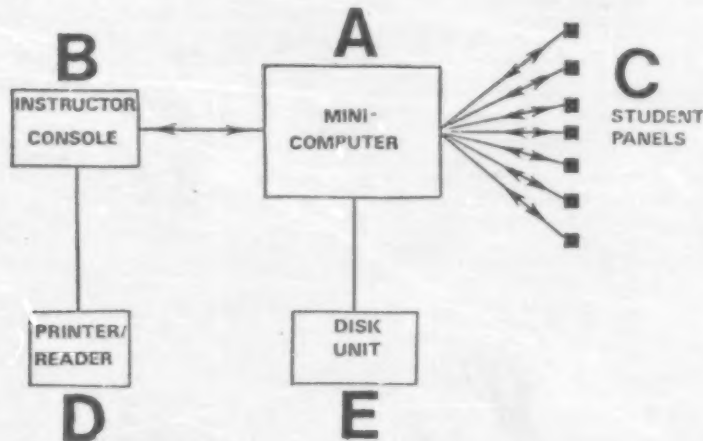


figure 1

The student receives information by means of messages which appear in the viewing window or by means of a light situated in the viewing window which flashes at certain speeds when supplying certain information. For example, if a student enters an answer into the system, feedback can be given to the student by making the light flash with a very high frequency if the answer is correct. The interaction of these components enables the students and the instructor to be in constant communication with each other, whatever teaching situation may be taking place.

The Cybercom system may be used in different modes of operation. The two basic modes are the social and individual modes. If the system is employed in the social mode then all the students react simultaneously to some stimulus. The teaching areas where this mode can be used are the lecture and the discussion. If the system is inserted into the individual mode, then students can proceed at their own pace. Two areas where this mode could be employed is in self-paced learning and testing or grading. The system keeps a record of every student's progress, which is available to the instructor. In this sense the, the system is being employed in a computer managed instruction manner (CMI) in addition to

computer aided instruction (CAI). The diagram in figure 2 indicates the mode choices which the instructor has when using the system.

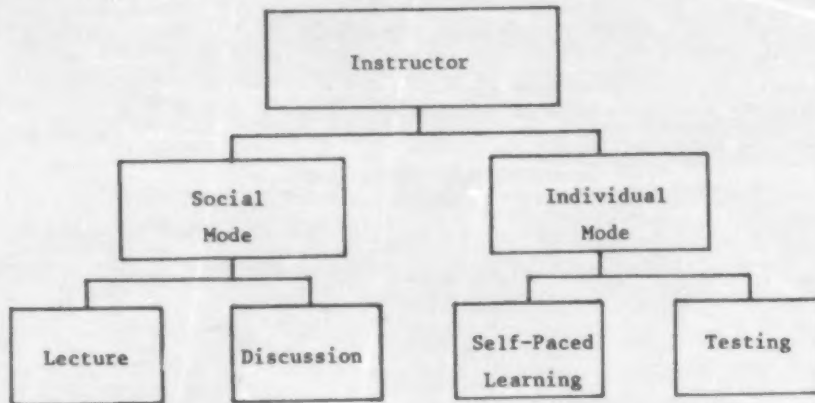


figure 2

In addition to storing all the information which is entered, the system will also produce a battery of reports and analyses. These reports provide details of the group's performance and information about an individual's progress. The reports and analyses can be requested at any time during a lesson and a hard copy of the final report and analysis can be produced at the end of the lesson/lecture.

The operational flexibility of the system enables it to be used in various modes in order to meet particular needs, many of which have not been mentioned in this general outline. More detailed descriptions of the Cybercom system are available [2;10;11;12].

In order to evaluate the instructional effectiveness of the televised lectures, the Cybercom system is used in the social mode. The students are asked to respond simultaneously to the questions which are posed at various points in the lectures. They enter their answers into the keyboards and the system records their responses. It is now possible to provide students with immediate feedback by using the light in the keyboard to inform them if their answers are correct. It is not possible to display the correct answers to the students; this is done in the form of delayed feedback at the completion of the lecture when the answers appear on the television monitor. Thus this study examined the effect of compressing the time lapse between feedback, where the immediate feedback only informed the students if their answers were right or wrong and the delayed feedback displayed the correct answer. Before the results of the study are discussed, some research findings on the nature and effects of feedback will be outlined.

FEEDBACK

Research conducted on the instructional effectiveness of feedback has not always resulted in directed and definite conclusions. Many studies in fact show results which could almost be considered contradictory. The term 'feedback' is used in this paper to encompass any of the procedures that are employed to tell a learner if an instructional response is right or wrong. This will include terms which have been evolved to describe various types of feedback, such as Knowledge of Response (KR), Knowledge of the correct response (KCR), Correctional Review (CR), and so on.

Most researchers have found that when students are given feedback during instruction their achievement in test scores improves [13]. In a review on the analysis and application of media, Levie and Dickie [4] claim that some general conclusions on feedback are that feedback that provides the correct answer is better than merely telling the learner that he was wrong and feedback is most effective when provided immediately following the response. However, many studies can be found which do not always support these claims.

For example, a study [14] involving two groups of students in a computer-controlled lesson about heart disease, where one group was given feedback only when the responses were correct and the other only when responding incorrectly, resulted in no significant differences in achievement. This finding tends to contradict the Skinner propounded belief that feedback which rewards correct responses or actions encourages learning. Research on the so-called Delay-Retention Effect (DRE) has shown repeatedly that delaying the presentation of feedback for a day or more leads to significant increases in what students remember on a retention test [13]. In an attempt to explain this apparent anomaly, Kulhavy and Anderson [15] contend that wrong responses interact negatively with the ability to acquire the correct answer when the student sees feedback; a result which appears to question the claim that more positive results are obtained when feedback provides the correct answer.

Kulhavy [13], in an educational review on feedback, proposes that many of these opposing results could be due to the conviction that all immediate feedback acts as a reinforcing event which was a view strongly supported by operant psychologists during the development of the programmed instruction movement. He states that as this idea had so much support it is "no surprise that scholars have worked overtime to fit the round peg of feedback into the square hole of reinforcement." [13, p 213]. It is probable that only feedback which reinforces is of value and it cannot be assumed that all feedback reinforces - only that which reinforces is a reinforcer. It is quite possible that the misconceptions regarding the function of feedback have caused many of these apparently diffuse research results.

Thus the present study was not presented with a background to feedback which provided a clear prediction of the effect the immediate feedback would have on student achievement. It was suspected that there would be no significant differences due to two factors. Although the general belief is that immediate feedback is better, the time gap between the immediate feedback and the delayed feedback was not large. Secondly the nature of the immediate feedback - informing the students if they are right or wrong - is again mostly considered to be inferior to providing the correct answer.

METHOD

Subjects

Participants were first year commerce students at the University of the Witwatersrand who were enrolled for an introductory service course in statistics. The study was conducted over 2 blocks ($\frac{1}{2}$ year) with 354 students. The students participated in the experiment as part of the normal course in introductory statistics and were unaware that data was being collected to measure the effects of immediate feedback. The tests which they wrote constituted part of the course.

Materials

The stimulus material consisted of 6 televised lectures on discrete probability distributions which were produced with the earlier described structure. The titles of the six lectures are:

1. Probability Distributions.
2. Expected Value of a Discrete Random Variable.
3. The Variance of a Discrete Random Variable.
4. The Binomial Probability Distribution.
5. Properties of the Binomial Distribution.
6. The Poisson Probability Distribution.

Procedure

The 354 students were tested regularly over a period of two quarters after they had viewed each unit of televised lectures. A unit consisted of 6 lectures which dealt with some topic on introductory statistics. These tests acted as a standard for comparison when the experiment was conducted. A sample of 64 students (the experimental group) was selected so that their results over all the tests did not differ significantly from the remaining 290 students (the control group). The two groups were then shown the 6 lectures produced for the study. The experimental group was given immediate feedback via the Cybercom system as

to whether or not their answers were correct. It must be remembered that both groups received delayed feedback when the answers to the questions were displayed at the end of each lecture. Thus the only variable which was changed in the experimental group was the timing of the feedback.

Once the students had viewed the six lectures, they were tested on the topic which had been covered. The difference between this test mark and the other test marks was then compared for the two groups. If the effect of the immediate feedback has no influence on student achievement then the results of the experimental group should not differ from those achieved by the control group. Thus the null hypothesis to be tested is that there is no significant difference between the difference in test results achieved by the two groups.

RESULTS

The tests conducted at the completion of each unit of lectures had established that the results of the two groups possessed independent normal distributions with approximately equal standard deviations. Thus a t-test was conducted in order to determine any significant differences in their results at the conclusion of the experiment, although the standard normal variable z , could have been used in view of the large sample sizes. The results of the test are given in table 1. The experimental group achieved significantly better results at the 95% level of confidence which indicates that the null hypothesis should be rejected. The immediate feedback had enabled the achievement of significantly better test scores.

Table 1: t-test Results

	n	Mean	Std Dev	Std Error	t	D.F.	Prob > t
Control Group	290	6,69	17,40	1,02	-3,15	352	0,0017
Experimental Group	64	14,34	18,24	2,28			

DISCUSSION

These results do not support the claims made by some of the studies on the Delay-Retention Effect but rather conform to the more general belief that feedback is most effective when provided immediately following the response. The reasons why the immediate feedback caused improved achievement are not directly discernible from this study. What can be deduced however is that the feedback did act as reinforcement because the students' achievement improved. The reinforcement which occurred could be explained by considering two possibilities.

First, the immediate feedback could act as an extrinsic reinforcer. In other words, telling the student whether the response is right or wrong does not

lead to increased learning. It is rather the desire on the part of the student, to answer correctly and be rewarded by receiving immediate approval, which might heighten learning. However, research has shown that extrinsic reinforcement has little effect on achievement [13].

Secondly, the reinforcement could be due to learner expectations. Kulhavy [13] claims that the level of confidence which a student has about being correct when he responds has a direct bearing on the effectiveness of feedback. For example, when a student has high response confidence, feedback probably receives only slight attention when the response is correct since it merely serves to confirm the student's assessment. However if the answer is wrong, the student is likely to spend a substantial amount of time in trying to locate the source of the error as missing the question might cause the student to become incensed. If the response confidence is low, it is doubtful whether feedback is of much use as the student is probably in need of other teaching strategies to improve understanding, rather than feedback.

In this experiment it is quite possible that learner confidence was high when responding to the questions, as students tend to believe they understand what the lecturer is saying, given that the lecture is clear and well structured. However, as the error response rate was relatively high (~ 40%) the students receiving immediate feedback could have become more incensed at missing the question than the delayed feedback group and therefore spent more time tracing and correcting errors.

Although this study has shown improved achievement when using immediate feedback, the results only apply to the type of teaching medium (uniquely structured television lectures) and the nature of the subject being taught. Thus any general conclusions which one might be tempted to draw may be misleading.

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COMPUTER-ASSISTED COMPETENCY-BASED TRAINING OF MATHEMATICS TEACHERS

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ABSTRACT

Competency-based teacher training is an attempt to solve some of the most urgent problems in the education field. In competency-based teacher training certain skills of the teacher are identified. These skills are then practiced in simulated micro teaching situations. Specific competencies of the mathematics teacher include drill and practice, questioning, focus, contextualization, diagnosis and remedial teaching.

Computer assisted instruction is a powerful aid in the realization of some of these skills. The use of the computer or micro-computer makes it more easy to attain the goals set by competency-based training programmes. In computer-assisted training the following modes are used: drill and practice, tutorial, problem solving, free dialogue and simulation.

At the Potchefstroom University for Christian Higher Education research is being done to determine the effect of computer-assisted instruction on the competency-based training of teachers.

COMPUTER-ASSISTED COMPETENCY BASED TRAINING OF MATHEMATICS TEACHERS

1. INTRODUCTION

It is typical of our time that ever greater demands are made on the effectiveness of the teaching and education of our young people. According to the HSRC report on Provision of Education in the RSA we are facing daunting educational challenges in South Africa.

There are large numbers of Black pupils on primary and secondary school level and they will continue increasing, there is an urgent demand for technological training, there is an educational gap amongst adults of all races which must be bridged and on top of all this there is also an alarming shortage of teachers in certain key subjects such as Mathematics and Science.

Development in technology and microtechnology - the 80's have been called the age of fiche and chips - has influenced education considerably. Classrooms have been flooded by a mass of teaching aids. These versatile teaching aids, of which the computer is the most spectacular, offer new possibilities to the teacher of the 80's, but also make greater demands on him.

We are interested in what the institutions for the training of teachers can offer their students to meet these demands. Teaching Science identified specific teaching skills. This led to competency-based teacher education.

The use of the computer as a teaching aid led to what is known as computer-assisted instruction (CAI). Because of these developments Media Science grew into an independent discipline of Education.

In this paper I am going to illustrate that computer-assisted instruction can form an important part of the competency based education of teachers, and more specifically of mathematics teachers. First the concept "competency-based teacher education" will be discussed and then I will try to show how the computer can be used to help the mathematics teacher to acquire certain skills.

2. COMPETENCY-BASED TEACHER EDUCATION

2.1 DEFINITION

Competency-based teacher education is to train student teachers in terms of clearly specified discernible and objectively measurable aims and goals.

According to Stan Elam competency-based teacher education is a programme in which "performance goals are specified and agreed to, in rigorous details in advance on instruction. The student must either be able to demonstrate his ability to promote desirable learning or exhibit behaviors known to promote it. He is held accountable not for passing grades, but for attaining a given level of competency in performing the essential tasks of teaching" (1).

2.2 SOME CHARACTERISTICS OF COMPETENCY-BASED TEACHER EDUCATION

In a competency-based teacher training programme certain skills and attitudes characteristic of a successful teacher must be identified before training begins. Each identified skill has certain minimum requirements which each student must attain. Thus criterion-referenced evaluation will be applicable.

This new approach developed because the public demanded accountability, relevance and cost-efficiency in the training of teachers. It was no longer acceptable that teaching skills were regarded as mainly innate and dependent on a teacher's personality traits such as the ability to get along with other people, to motivate and to lead them, to think in an original way and to be well organized. Competency-based teacher education wants to establish a thorough empirical base for teacher education in which certain teaching skills are defined.

Because criterion-referenced education plays such an important role in competency-based teacher training, the student himself sets the tempo of his training. Competency-based teacher training is therefore also individualised.

Here the first big problem arises. The conventional lecture method traditionally followed in teacher training at universities and colleges was group orientated and was not aimed at the individual student. It is in fact impossible to give individual training in a group of thirty to two hundred or more students.

The first attempt to solve this problem was micro-education. In a simulated classroom situation the opportunity was given to a small group of students to practise certain teaching skills - skills like the motivation of pupils, continuity of subject-matter, introduction to new subject-matter, the application of newly acquired subject-matter in practical situations, the asking of questions, revision, diagnosis and remedial teaching.

The computer, especially the micro-computer offers wonderful new possibilities as an aid in competency-based teacher training.

2.3 COMPETENCIES OF THE MATHEMATICS TEACHER

The training of mathematics teachers lends itself to a competency-based approach because certain skills necessary for the teaching of mathematics can easily be identified - skills such as the drilling and practice of rote knowledge, graphical representation, questioning, problemsolving, symbolizing and generalization, application, diagnosis and remedial teaching.

Some of these skills will be discussed and attention will be given to the problems a teacher has in teaching these skills in the traditional classroom situation.

2.3.1 DRILL AND PRACTICE

One of the problems a maths teacher has to face is that a large percentage of the subject matter to be taught consists of rote

knowledge that can only be mastered by the pupils through constant drill and practice. The present approach to mathematics, however, emphasizes insight to such an extent that not enough attention can be given to drill and practice.

It is nevertheless an undeniable fact that the modern maths teacher must be an expert in the skill of drill and practice. He must be able to present drill exercises in the classroom in an interesting way so that he can achieve the desired results. A lack of time because of short periods and an overloaded syllabus as well as large classes are restraining elements which frustrate the teacher in achieving his goals. The computer can perhaps offer the much needed solution to this problem.

2.3.2 THE PRESENTATION OF NEW SUBJECT MATTER

During this important stage in the course of the lesson quite a few teaching skills are implemented, for instance graphical representation, symbolizing and generalizing, questioning, contextualization and focus. In the traditional classroom situation the maths teacher is again confronted by the same problems he experienced with drill and practice.

To solve these problems we will have to study some basic modes of computer assisted instruction such as the solving of problems, free dialogue, simulation and the presentation of new subject matter.

2.3.3 THE SOLVING OF PROBLEMS

This skill is of vital importance in the teaching of mathematics with insight. Insight is, in fact the ability to solve a new unknown problem using existing rote knowledge. All maths teaching leads to the ability to solve problems. A maths teacher must therefore be well-trained to lead his pupils to be able to solve problems intelligently.

2.3.4 DIAGNOSIS AND REMEDIAL WORK

Because mathematics is the key to so many branches of learning, the subject is taken by a large number of pupils. Many of these pupils soon develop learning problems in mathematics. The maths teacher must therefore be able to diagnose these problems skilfully and to do the relevant remedial work. Remedial work is usually time-consuming and also requires an individual approach. This is usually not possible in the traditional classroom situation.

3. COMPUTER-ASSISTED INSTRUCTION

3.1 FUNDAMENTAL PERSPECTIVE

The computer is very versatile and powerful, but it always remains only a teaching aid which can never replace the teacher. Fundamental educationalists need therefore not be alarmed that education will be dehumanized by the computer or the teacher driven from his classroom. Although the computer is a wonderful technological

Apparatus, with endless possibilities and new perspectives as a teaching aid, it can never replace the teacher because education is always more than merely neutral teaching and learning. Religious forming and the development of ethical norms are important components of education.

To achieve this the interpersonal interaction between adult and child and the influence of the adult on the child are indispensable.

The computer offers wonderful challenges to educationalists, especially to those specializing in didactics and teaching science. They can do research on the place and value of the computer in education, the possibilities and limitations of computer-assisted instruction and the educational and didactical base of computer-assisted instruction.

These two new developments in teaching, namely competency based teacher education and computer assisted instruction can lead to a wonderful renewal in teaching and develop into a new branch of didactics, namely competency-based didactics. Although this new branch is still in its experimental stage, it already exhibits the following characteristics.

- * The concept of individuality is basic to the new didactics.
- * Maximum use of modern technological aids is most important in competency-based didactics.
- * Students and pupils master subject matter systematically. Mastering is controlled by continuous formative evaluation. Thus mastery learning strategy is very prominent.
- * In competency-based didactics aims and goals play a major role.
- * All students must eventually reach the same academic level, but each one at his own tempo. Mastery learning strategy is again important.

3.2 TEACHING-POSSIBILITIES OF THE COMPUTER AND SKILLS OF THE MATHS TEACHER

In teaching the computer can be used in many ways. The following teaching modes relevant to the maths teacher will now be discussed; drill and practice, presentation, problem-solving and free dialogue.

3.2.1 DRILL AND PRACTICE

This is the simplest form of computer-assisted instruction because certain basic skills like speed and accuracy in the application of the four main operations in maths, addition, subtraction, multiplication and division must be practised. The pupil can, for instance, do the multiplication of algebraic binomials by means of a computer programme. The big advantage is that the computer can give the pupil individual help while he is doing the exercise. Mistakes are immediately identified and the pupil can

correct them on the spot. According to the traditional method the pupil did a number of the same type of sums in his exercise book. These were marked by the teacher the next day, or week, or month or never. Often a pupil could have had a whole exercise wrong and feedback never took place. With the computer remedial work is done immediately.

The drawbacks of the traditional classroom situation are multiple: time is used uneconomically, individualization is very rare, pupils are not actively involved, feedback and remedial work is slow and the teacher is burdened with masses of work to be corrected.

When the same work is done with the assistance of the computer most of these problems are eliminated or at least diminished. Time is used more economically because each pupil is actively taking part and the pupil knows immediately if his efforts are correct. If not, he can try again after receiving commentary from the computer on his first effort. The computer also makes it possible for each pupil to work at his own tempo and at his own level: Clever pupils can also be given more difficult and challenging work. The principle of individualization is thus met.

After completion of the exercise the computer can give each individual pupil a report on his work. The teacher also gets an outprint showing him in detail the progress of each pupil.

The full 30 minutes of the period can thus be used effectively by each pupil. The benefits are enormous: each pupil did a few correct sums, each one has a report on his progress, the teacher knows exactly how his pupils performed and can thus give individualized exercises for homework where necessary. During the 30 minutes of the period the teacher was also free to give individual help, to remedy, inspire, admonish and exhort.

This method of computer-assisted instruction thus emphasizes pre-active skills like the planning of lessons, formulation of goals as well as interactive skills like diagnosis and remedial work.

3.2.2 THE PRESENTATION MODE IN COMPUTER-ASSISTED INSTRUCTION

This mode, also called the "tutorial" is more complex than the drill and practice mode. New subject-matter is now presented and more sophisticated answers requiring a higher degree of reasoning and originality are expected.

This mode is most suitable for presenting new subject-matter. Subject-matter well suited to this mode is set theory, exponents, logarithms, sequences and progressions and trigonometry.

In presenting new subject matter the teacher must possess the following skills: he must be able to ask the right questions, to focus the pupils' attention on certain aspects of the subject matter and be adept in contextualization.

3.2.3 THE SOLVING OF PROBLEMS

In this mode computer-assisted instruction is used in the solving of problems.

Because problem-solving and maths are interwoven, it is logical that this mode is widely applied in maths-teaching.

In the first classes of secondary school the computer can be used to "translate" sentences into algebraic expressions. This leads to the formulation of "equations" and their solutions.

Symbolizing and abstraction are thus very prominent.

In this mode the computer can create a new unknown situation for the student who already has all the knowledge and skill necessary for the solution of the problem. In some cases the student may not have all the necessary information. This is then supplied by the computer.

3.2.4 FREE DIALOGUE

These programmes are less formally constructed but are not without restrictions. This mode is an effort at natural dialogue between student and computer. The student may ask questions and suggest solutions at any time. This mode is still only at the first stages of development and is not yet widely implemented.

The maths teacher who wants to use this type of programme must be a most experienced teacher, with a thorough knowledge of his subject, children and the way in which they think. He must be able to anticipate all the possible ways in which a pupil may react to a certain question and supply answers to them all in his programme. Once again, teaching skills such as the asking of questions, diagnosis, remedial work and focus are important.

3.2.5 GAMES AND SIMULATION

In this mode of computer assisted instruction the computer is used to imitate real situations found in nature or culture. A model is used which reacts exactly as in real life or in a real situation. This mode makes it possible to side-step dangerous situations, to simulate expensive experiments and it also of course saves a lot of time.

As far as mathematics is concerned, games which include sequences and progressions, graphs and ballistics can be useful.

4. THE IMPLICATIONS OF COMPUTER-ASSISTED INSTRUCTION IN COMPETENCY-BASED TEACHER TRAINING

4.1 SHORTCOMINGS OF THE TRADITIONAL TEACHING PROGRAMME WHICH CAN BE ELIMINATED BY A COMPETENCY-BASED APPROACH

- * The traditional curriculum, especially on tertiary level,

exhibits a lack of variety. All students study the same subject matter, use the same textbooks, do the same tasks and write the same examinations.

- * Individualization is neglected. This leads to the absence of motivation, diagnosis and remedial work. Because there are just too many students, a lecturer is forced to use a one-way-lecture strategy.
- * Subject matter is over simplified to accommodate the large number of students.
- * Teacher training is too theoretical. Practical teaching problems are side-stepped because of too little time and too many students.
- * Technological teaching aids are not fully implemented.

4.2 THE ADVANTAGES OF COMPUTER-ASSISTED INSTRUCTION IN COMPETENCY-BASED TEACHER TRAINING

- * Programmes, covering all possible skills can be prepared. The student then chooses those he needs (after a diagnosis has been made in a micro-teaching situation).
- * Students do only those programmes they need individually. This can improve the students' attitude toward teacher training.
- * The students can start at different levels.
- * They work at their own tempo.
- * They work more purposefully.
- * Self-evaluation can be applied by means of evaluation programmes.
- * Student and lecturer can work more closely together.
- * Differentiation is possible to a much larger degree.

5. CONCLUSION

At the University of Potchefstroom research is being done on competency-based teacher training. The HSRC is assisting this project. One of the facets of this research is the role of computer-assisted instruction in the competency-based training of maths teachers. With the help of a research assistant a preliminary literature study has been completed. In 1982 empirical studies will be done to establish to what degree the use of the computer can improve certain teaching skills of prospective maths teachers.

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MICROWAT - A PERSONAL WORKSTATION OF MODULAR DESIGN

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ABSTRACT

Increases in volumes and functional requirements present challenges to the University of Waterloo to provide a steady improvement in its computing services. Recently the personal work station and local area networks have been receiving considerable attention. This paper describes the microWAT, a microcomputer system developed at Waterloo. Both the hardware and software design are outlined, together with a list of possible application areas. The paper concludes with an indication of future planning direction.

Introduction

Over the years the University of Waterloo has developed academic programmes which have been rich in traditional material, but which have had a pragmatic flavour as well. As a growing industrial nation, Canada has an insatiable requirement for people with state-of-the-art technical and managerial skills, and our government has encouraged us to enter into "mission-oriented" projects. The University of Waterloo was founded as a technologically-oriented university and so it follows that Waterloo would develop a broad requirement for computing, and indeed it has. Today we have a very large Computer Science programme, and computer techniques are used in all faculties, wherever appropriate. During the term, at least 25,000 accounted "jobs" are run each day, but many more are run on special equipment not under the supervision of the Department of Computing Services, and are not counted. This volume of computer use has created the following challenges.

- (i) There are never enough facilities to provide for every requirement. It is, therefore, important to find the most economical means of providing computer services.
- (ii) The services offered must be versatile, with many computer languages and flexible hardware facilities such as a selection of standard or special-purpose input-output devices.
- (iii) The facilities must be easy to use to enable those with a non-computer background to be productive. In other words, the economies strived for in (i) must not be achieved at the expense of the student or researcher.

These challenges have been with us for 20 years. Time has changed only the volume and applications. To meet the challenges, many systems have been developed over the years; they include WATFOR, WATBOL, cafeteria-style computing and WIDJET. To a certain extent these systems have become dated, and there is a constant search for better solutions. Currently, most universities are exploring the microprocessor and its application in the personal workstation with local area networks. This paper describes the microWAT, which is a personal workstation developed at the University of Waterloo during the fall of 1980, and which is meant to meet some of the challenges.

MICROWAT

A brief study conducted in 1979 confirmed that many of the jobs run on computers at Waterloo could be done using the computational capacity possessed by microcomputers or personal workstations. The major problem was the lack of proper software and the lack of appropriate input/output facilities. It seemed reasonable to develop the necessary software as we had been doing for years for the larger machines. However, the hardware presented new challenges. None of the inexpensive, mass-produced microcomputers had the appropriate hardware to operate our planned software, mainly because the memory was not large enough, and because there was insufficient flexibility, particularly with respect to input/output. It was noted that on campus we had more than 1000

"dumb" ASCII terminals, mostly with CRTs and keyboards, and a study was initiated to consider the problems of their conversion to personal workstations meeting our specifications. This study led to the design of the microWAT, a prototype of which became operational in December 1980. Dozens were produced in 1981, and are in use at Waterloo and other locations.

Hardware Considerations

The study of our ASCII terminals soon revealed that they were of various designs, but all had the common property of an RS232 interface. By using this interface, some additional circuitry (which is the microWAT) could be used to upgrade any terminal, and only the software would need to be modified to recognize the differences in screen, keyboards and baud rate. The microWAT would, therefore, be a small microprocessor system which uses its own RS232 interface to communicate with the ASCII terminal.

The Motorola 6809 microprocessor was chosen as the CPU for the microWAT over the popular Z80 and 6502 chips mainly because it has 16-bit internal registers. This made it much easier to prepare the software. It shared with the Z80 and 6502 the properties of being readily available, inexpensive, and having a large family of other compatible chips.

We decided to build the microWAT in a highly modular fashion. The basic unit consists of only a single 4.5" x 6.5" printed circuit board. This board contains the CPU, clock, 12K bytes of ROM or EPROM and two RS232 interfaces. This "CPU board" (as with the others in the set) obtains its power either from the ASCII terminal or a separate power-supply module.

An additional 48K of RAM is made available on a second 4.5" x 6.5" board. This implies that a bus structure has to be selected, and after much consideration a 6809-specific bus structure was chosen rather than a standard such as the S-100. By doing this we closed the door on much off-the-shelf hardware, but we were able to keep the physical size of the microWAT quite small.

The 48K RAM card together with the 12K of ROM available on the CPU card means that 60K of the 64K of addressability has been utilized. The extra 4K is located from 9000-9FFF hex and another RAM card was designed which has 64K arranged as 16 replications or "banks" of this 4K address space. These banks can be selected by "storing" a number from 0 to 15 into a specifically allocated I/O address. It was possible using specially-designed software to write the major portion of our language interpreters so they are stored in this memory. This leaves most of the 48K RAM memory available as work space to the user. The 12K of ROM on the CPU card is used for the bootstrap monitor plus the "root" for the bank-switching component of the system.

This bank-switching architecture extends itself to more than one 64K RAM card, so if necessary a software system can be fairly large. As well, we designed a 60K ROM card which has space for 15 ROMs or EPROMs each of 4K in size. These are also "bank-switched" to occupy the same 9000-9FFF address space. Of course, you may use more than one ROM card in the system. This means that the entire software system can become firmware, provided the code is written using appropriate conventions.

One of the reasons for choosing the microWAT design was to provide good flexibility with respect to input/output. One convenient I/O card which was designed and heavily used is the IEEE-488 bus interface. This permits us to use many devices such as disks, printers and plotters which are readily available and inexpensive. Other I/O cards have been designed for the microWAT, especially for use in networking applications.

In summary, the microWAT is a system of one or more circuit boards mounted on a rather simple bus. A typical system consists of 4 cards, namely the CPU card, 48K RAM card, 64K bank-switched RAM card and the IEEE-488 bus interface card. This system can be mounted inside most of our ASCII terminals, and uses their power supply. It converts the terminal into a personal workstation which has considerable versatility, with access to diskette drives, printers, plotters and extensive software systems. If desired or necessary, the microWAT can be mounted in its own chassis which has its own power supply. In fact, it can be placed at a location remote from the terminal in case security is a problem.

Waterloo micro Software Systems

Once the flexible microWAT design was chosen, it gave considerable latitude to the software developers. In most microcomputing systems, the language interpreters have to occupy the same 64K address space as the monitor, library and user program and work area. This seriously restricts the size of the interpreter, with a corresponding negative impact on the scope of implementation of the software. With the bank-switching architecture, the software system can occupy whatever space it requires; the cost is simply another bank-switched RAM or ROM card when necessary.

This flexibility permitted us to develop extensive implementations of the following languages:

APL
FORTRAN
COBOL
Pascal
BASIC

These implementations are all interpreters, which provide a "friendly" environment for debugging. Of course, APL is always implemented as an interpreter, and BASIC usually has been. However, it is not usual to find COBOL, Pascal and FORTRAN implemented as interpreters, and their users have reported a level of satisfaction usually experienced only by APL and BASIC users.

These language systems operate using a common library of routines, many of them related to input/output and other system specific functions. This common library normally permits a simple interface to whatever operating system is being used. This will be further discussed in a subsequent section.

The system also contains an editor which can be used either in a full-screen or line-oriented mode, depending upon the ASCII terminal being used.

A 6809 microprocessor Assembler Development system was also prepared, and runs on the microWAT. It has a number of important features, some of which are:

- (i) It includes a special linker which permits the assembly language programmer to use the bank-switching hardware with literally no effort.
- (ii) It uses an extensive assembler including Waterloo's structured macros which permits the user to write "branchless" assembler code for ease of readability and subsequent maintenance.
- (iii) It gives the assembler user access to the common system library mentioned earlier.

All of the Waterloo micro software systems were written using a special systems development language called the Waterloo Systems Language. It is usually referred to as WSL (pronounced "whistle"), and this system is also available on the microWAT. In fact, the system library we have mentioned, is more appropriately referred to as the WSL library, since it is available to WSL and all software which has been prepared using WSL. Of course, the library is written in WSL, and it follows that the WSL compiler is itself written using WSL. More details about WSL can be found in the article listed in the references.

Software Portability

When the 6809 was chosen as the microprocessor for the microWAT, we realized it would have a limited useful lifetime. In fact, more advanced chips such as the 68000, 8086, 8088 and Z8000 were already announced, and some were even available. It would, therefore, be unwise to prepare extensive software systems specifically for the 6809. The systems language WSL is meant to produce code which is portable. By using WSL to write the language interpreters, the editor, the library, the assembler development system, and in fact the WSL compiler itself, it becomes a relatively easy job to move or "port" the system to other machines and interface it with their operating systems. To date the system has become operational on the IBM personal computer under DOS (8088 processor) and on the IBM 370 using VM/CMS. We are currently porting it to operate on the DEC VAX and have begun working with the 68000 microprocessor.

Operating Systems

The current microWAT system does not use a traditional operating system such as CPM. Much of the function of such an operating system is related to file control on diskettes and printers. We were familiar with the system used by the Commodore PET where these elements of the operating systems are distributed to CPU's contained in the disks and printers. This architecture removes a load from the microWAT CPU and provides extra memory for buffers which normally would be taken from the users' space.

These "intelligent" peripherals are connected to the IEEE-488 bus which is supported by the microWAT. It follows that the microWAT requires a much smaller "operating system"; we prefer to

call it a monitor as it is only a simple interface between the WSL library and the IEEE bus, RS232 lines, and other I/O facilities which may be employed.

If we decide to use other non-intelligent I/O systems with the microWAT, we may consider developing a small operating system. It probably would be CPM-compatible to maintain consistency in the industry.

The microWAT as a Systems Component

The previous sections generally describe the various hardware and software components of the microWAT. This section is meant to outline some of the ways in which it can be integrated into our computing environment at Waterloo.

- (i) A stand-alone personal computer: If you possess an ASCII terminal, the microWAT turns it into a multi-language personal computer. If you require a printer or diskettes for storage of data and programs, you can purchase off-the-shelf hardware which is supported by the WSL library interface to the IEEE-488 bus. In a similar way you can use plotters or any other IEEE-488 peripheral device, provided you make appropriate extensions to the WSL library, or include the appropriate code in your own program.
- (ii) A special-purpose stand-alone personal computer: Since the microWAT can use a ROM card to house the software as firmware, it is possible to tailor your system to be language specific. For example, the terminal could become a Pascal workstation without having to load the software from some external storage medium.
- (iii) A combination ASCII terminal and personal computer: Since the microWAT CPU card contains two RS232 devices, it is possible to connect the microWAT to both the ASCII terminal, and a medium-or large-scale host computer. One application of this is to permit the user to employ the ASCII terminal in "pass through" mode, thus effectively bypassing the microWAT. In this way the ASCII terminal reverts to its original role as a "dumb" terminal to the host computer.
- (iv) A personal workstation using host computer files: Since an RS232 interface connection is available between the microWAT and the host computer, it is possible for software running on the microWAT to be reading and writing files on the IBM 370 system. This is accomplished by using a special simple program called HOSTCM (host communications module) which is a CMS job running on the 370. The WSL library has a system facility which permits it to recognize file names with the prefix "HOST.". When I/C is executed involving such a file, the WSL library communicates with HOSTCM using the RS232 interface, and the appropriate information is passed between the host and the microWAT. Thus HOSTCM either causes the data to be written into a CMS file, or it reads the required data from the CMS file and transfers it to the microWAT. This feature, while slow, permits the user to access host files when the application

requires it. For example, (a) the microWAT can have periodic access to a large data base stored on the host, (b) the microWAT can write a file to special peripherals such as a high-quality printer on the host, or (c) the microWAT can use the host file system for archiving and de-archiving of programs.

- (v) A component in a distributed processing system: The host computer and the microWAT can carry on a conversation along the RS232 line. Thus a system can be developed which divides processing between the host and the microWAT. Of course, two microWATs can be used with each other in the same way.
- (vi) A host program-preparation system: Since all the language processors operate on the IBM 370 exactly as they do on the microWAT, programs can be prepared and debugged on the smaller machine, and can eventually be run in production on the host machine which has larger memory and is faster. This feature is particularly useful for students who may run out of capacity on the microWAT before their assignment has reached completion. They can transfer their programs and data to the IBM 370, and use the larger system to complete the project.

Availability of microWAT Systems

The microWAT system is manufactured for the University of Waterloo by Northern Digital Ltd., a small company located in Waterloo. Another version is available incorporated as part of the Highly Intelligent Terminal System (HITS) manufactured by the Volker-Craig Division of the MABU Corporation, also located in Waterloo. A third version is available from BMB Compuscience in Milton, Ontario, who employ a 2 megahertz system (the others are 1 megahertz). Commodore has incorporated the microWAT circuitry into its SuperPET system which is available in many parts of the world. All of these systems operate using the 6809 microprocessor, and all use the Waterloo micro software systems.

Future Plans

The microWAT has proven to be a valuable contribution toward meeting the challenges described at the beginning of the paper. However, as has always been our experience, it has introduced new challenges. For example, it is clear that all such workstations should have access to a high-speed local area network (LAN) so they can share data and peripheral devices without having to use the IBM 370 as a host. This would not only be more economical, but faster as well. Experiments are now being conducted with early versions of off-the-shelf networks, and some development is being done toward implementing our own. One such effort in the latter category involves using the IBM Series/1 as a file server and printer for 32 microWATs. Since September 1981 we have used such a system, and have installed a second one in January 1982. These installations are considered to be interim solutions until an effective and economical LAN is put into operation.

The microWAT is only our first attempt at designing and building a personal workstation. We plan to incorporate other

microprocessors into microWAT, and to port the micro software to other personal workstations, including the many which are now available on the open market.

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THE USE OF THE CYBERCOM IN RESEARCH AND TEACHER TRAINING AT THE RAU

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ABSTRACT

Main features of the CYBERCOM are described. It is shown how the CYBERCOM as a computer not only strengthens the teacher's guidance of pupils in classroom situations, but also visually displays and permanently records classroom interaction. Likewise the CYBERCOM facilitates evaluation procedures. In research and teacher training the CYBERCOM is used in planning, presenting and evaluating teaching strategies. Interaction analysis can be incorporated in this research and teacher training.

The word CYBERCOM is derived from 'cybernetics' and 'communication' pointing at one of the most basic skills in teaching: the communicative guidance in the lesson. In ordinary lessons experienced teachers use a sixth or horse sense to determine what pupils follow and to what extent they follow. Although the expression on Johnny's or Ann's face as well as many tell tales of their bodily postures may reveal quite a lot to a teacher who really knows his pupils, it is at best intuitive and subjective.

The CYBERCOM is a computerised classroom in which some or all interactions are done, retrieved and stored electronically. Each pupil has a semblance of a type writer keyboard on his desk to answer questions. Each answer is displayed on a display unit or screen in front of the teacher. At a glance the teacher can see if all pupils answer questions and what each pupil answers. A small display unit or screen on the pupil's keyboard also reflects his answer and the answers can be rubbed out and changed. Answers are limited to 80 characteristics, 34 of which are displayed on a single line on the pupil's screen. Also on the student's keyboard is a button to ask for help or to indicate that he does not understand.

The CYBERCOM operates on a wide variety of modes on which a teacher can decide and teach by pressing certain buttons. The modes can be varied at random during the same lesson. A very brief synopsis of the modes are:

1. The Social open mode

The teacher merely poses any question (orally or in writing) and watches the responses on his screen. In an ordinary lecture students may be asked to comment briefly in telegram fashion on the goal set for a certain lesson. The lecturer then uses the responses as feedback and for further discussion in which he may or may not use the CYBERCOM. At any time any pupil can join in the discussion by responses on his keyboard.

2. The Social closed mode

One particular question is asked at a time. The pupils may get reinforcement for correct responses in that the teacher feed the correct answers in the programme. Correct answers are indicated on the student's screen by flashing lights which may appear at the final or concluding characteristic of the correct answer or at every characteristic of the correct answer. Test results, means, item analysis and many other data are immediately available either on the monitor or as computer printout.

3. The Individual mode

Here each pupil can work at his own tempo. A typical operation of the individual mode is multiple order questions or a set of other questions. Reinforcement may be given to the pupils as in the Social closed mode. The teacher can follow the progress of the pupils on his screen. At a glance he can see how far and how good the fast pupils are and how or if the weak pupils progress.

A typical way in which the CYBERCOM is used at RAU is the joint effort of a class to plan a lesson. From observation rooms with one way glass the fellow students watch one student giving the lesson to pupils. The responses of the pupils are also displayed on screens in the observation room. The fellow students or lecturer in the observation room can also communicate with the student teacher through a keyboard similar to that of the pupil.

The CYBERCOM can also be used for group formation and group work. Groups are divided according to feedback on the screen and different programmes can be used for each group.

This observation of a lesson becomes highly structured by incorporating interaction analysis. The Gresse Interaction Scale (1), for instance, measures the cognitive level at which the teacher teaches. A lecturer or fellow students can code the lesson from the observation room. The student teacher may think that his teaching is on a high cognitive level, see on the screen that the code indicates a low cognitive level and then adjust the teaching accordingly.

Research is being done on teaching strategies. Lessons on the same subject matter are planned using both a heuristic and ostensive teaching strategy (2-3). The interactions recorded by the CYBERCOM provides profuse data, in many ways more revealing than video recordings in that the individual response of each pupil is permanently available.

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Captions for photograph

1. General view of CYBERCOM
2. Teacher's screen and keyboard
3. Pupil's screen and monitor
4. The CYBERCOM'S computer printout

BRIDGING THE SCIENCE SCHOOL-UNIVERSITY GAP WITH COMPUTER-BASED EDUCATION

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ABSTRACT

The attrition and failure rate among first year Science students is a major problem confronting educators. The present paper discusses a program aimed at bridging the gap between School and University by making intensive use of Computer Based Education using the PLATO[®] system. First year students enrolled at the University of the Western Cape were tested for their knowledge of the Matriculation Chemistry syllabus, and then referred to lessons aimed at revising and reinforcing their knowledge. The student sample responded favourably to the program.

1. Introduction:

The lack of high level manpower in South Africa poses one of the most pressing problems on its communities. That this lack, particularly in the field of Science and Technology, is partly due to the high failure and drop-out rate at Universities and Technikons, has been recognized by the National Manpower Commission [1] and endorsed by the Government White Paper on the Report of that Commission [2].

The first-year failure rate which is taking place at our Universities is robbing South Africa of large numbers of potential scientists, engineers, medical doctors and technicians. This is surely totally unacceptable to a society such as ours which will become increasingly dependent on Science and Technology for its survival. From a cost effectiveness point of view, the high failure rate at our universities must be ranked as an economic disaster of no small measure. No industry could hope to survive if 80% of its potential products (as is the case at one of our universities) were to be discarded before reaching the market place. From a human point of view, an immense price is paid in frustration, despair and heartbreak, both from the student's point of view and their parents. The loss of trained scientific and technological manpower is surely and not so slowly vitiating the very foundations of our society, but since the price will only be paid in full by future generations, there is a tendency to let tomorrow look after itself.

This is not to say that the topic has not received attention. The Committee of University Principals held a symposium in September 1978, where the transition from School to University was discussed. [3] The problem was very much highlighted, but the symposium seems to be singularly short of practical solutions to solve it. And yet, it is the author's conviction that it is at the level of the Universities that the solution to this problem must be sought and applied. The reason for this is that in the first place, there is too large a backlog of suitably qualified Science and Mathematics teachers in our schools. (For those who like to peruse gloomy literature, I refer to the Report of the de Lange Commission [4]). While a giant effort might in the medium term relieve the shortage in the White Education Departments, the situation in Black schools is presently little short of catastrophic, and with the expected growth in Black school enrolment, only the most utopic visionary will see the hope of improvement in the medium term.

The Universities on the other hand are well placed to confront the problem of first-year failures, as they deal directly with the affected population, and

dispose of highly qualified staff. If we accept this premise, how can Universities address the problem of first-year failures? Even without the use of high technology, much can be done by considering alternative degree structures, lengthening of the academic year, curtailing social activities such as "rag", taking into account advances in educational psychology, and a general improvement in didactic methods and evaluation procedures.

Paradoxically enough, the fact that universities do possess highly qualified staff is in some ways counterproductive. In many cases, the teaching of first-year science courses is often entrusted to the tender mercies of young, relatively inexperienced lecturers, whose ability to survive the academic maelstrom has been amply demonstrated. Invariably, such personnel is of high research competence and motivation, and are masters of their narrow specialties. Are such people best suited to play a meaningful role in an intensive school-university bridging course? Is it fair to ask such persons to cut down on their research activities and thus hampering their prospects for professional recognition and academic advancement? Can anyone, for example, reasonably expect a young lecturer in Chemistry, hard at work towards a Ph.D., and initially appointed for his dynamism and productivity in research, to suddenly become the dedicated tutor of masses of unwilling captives of "service courses", and a brilliant innovator of didactic pyrotechnics?

This brings me to the point where high technology comes in. Computer Based Education (CBE) is not a gimmick or the toy of futuristically inclined boffins. It is a tried and tested method of supplementing conventional education, and is in widespread use overseas in schools, universities, and hospitals. It is successfully employed in highly demanding training situations, and has been shown to be cost effective. Can CBE be part of the solution to the first year failure rate? The present paper deals with an experiment carried out this year at the University of the Western Cape, where the high failure rate has long been a source of concern. It is the author's hope that it will add constructively to the solution of one of the most serious problems confronting educators today.

2. Objectives

The aim of this bridging program held in the Science Faculty of the University of the Western Cape was to provide an intensive revision of the Science and Mathematics Matriculation syllabus, by making use of computer based education. For the past two years a wide variety of departments of the University have made

increasing use of the PLATO system, and the recent installation of a dedicated mainframe serving a 64 terminal installation (presently the third largest such university system in the world) made such a bridging program a practical proposition.

The three departments taking part, Chemistry, Physics and Mathematics, were given a free hand as far as the use of on-line material was concerned. Chemistry opted for a thorough diagnostic testing program lasting the full three weeks, followed by exposure of the students to lessons covering the matriculation syllabus. An important consideration in deciding this particular course of action was the availability of testing material which had a strong instructive component (see section 4).

In addition, it was considered advisable to use the three-weeks bridging period as a transition period, in which students could be introduced to the University life more gradually than in the past, thus preparing them for the more formal educational process.

3. The Bridging Program:

For the purpose of the three weeks bridging experience, all formal lectures to the participating students were suspended. The students were divided into groups for the purpose of scheduling access to the terminals, which were made available according to a predetermined time-table during the day. Access could also be gained in the evenings till 24h00, and on Saturdays. Apart from work on PLATO, which comprised about 8 hr per subject spread over the three weeks, students were given lectures on the proper use of the University library, and had opportunities to meet with their course lecturers.

4. The test material:

The testing of students over a period of three weeks was carried out using the PLATO Learning Management (PLM) system. This is a software package supplied by Control Data Corporation to users of the PLATO system, and consists of testing modules comprising "instructional units" covering various selected learning objectives. In its normal use, PLM is admirably suited to manage computerized instruction, as it presents and marks questions, provides suitable feedbacks, and assigns a rich variety of learning resources.

Two courses were presented to the students:

4.1 The first one consisted of an introductory lesson on the use of the PLATO terminal, and this was followed by a demonstration PLM testing module, where students were introduced to the testing procedures, which make use of multiple choice questions (either by the choice of an appropriate distractor or the touching of sensitive areas of the terminal screen), matching type questions, true/false questions, and the input of numerical answers.

4.2 The second course consisted of the SASSC (South African School Science Curriculum) modules covering the Matriculation Chemistry syllabus. The thirteen modules used covered all aspects of the syllabus, with the exception of Organic Chemistry. The selection of this material was based on (i) its availability (the author wishes to place on record his appreciation to CDC (SA) for generously making these modules available prior to their official release), (ii) its comprehensive coverage of the matriculation syllabus, and (iii) its dual role both as testing and instructional material. The inherent disadvantages of the material were recognized prior to selection, and these were (i) the fact that these PLM modules had not been designed as diagnostic material, (ii) the very high standard not only of the questions, but of the mastery criteria set by their authors, and (iii) their availability only in English. Nevertheless, their instructional value were considered to be such as to outweigh these disadvantages. The participating students were informed that the "failing" of any of the tests would in no way count towards any academic record for the coming year.

Students were able to access the various modules in any order, and the PLM course control options set in such a way that only one test was allowed per module. This was in order to prevent the students to exercise a quite natural tendency to repeat a test in order to try to obtain a better score. Since the major object of the program was to afford opportunity for revision, students could take the on-line test with the help on any notes or books of their choice.

The PLM options which generate learning resources were turned off, as it would have meant that the diagnostic process would have been interrupted. Instead, the extensive data made available by the PLM system was scrutinized daily, and students who had completed the series of tests were enrolled in a group where a generous supply of lessons covering matriculation chemistry was supplied. These lessons will be made available throughout the year. Initially, it was envisaged that individual sequences of lessons would be assigned to each

student according to his needs, but in view of the students' general performance, it was considered advisable to allow the students to choose the material for themselves, and thus revise and reinforce all sections of the syllabus.

5. The Student Sample:

The students selected for the bridging program were all first-year students at the University of the Western Cape. Those students who had been enrolled in chemistry classes in previous years and had for one reason or another not gained a credit for a first year chemistry course were subjected to the same bridging program, but statistics on their performance do not form part of this discussion. The remainder had no contact with formal science education since leaving school. Of the 177 students who took the tests, 99 wrote their matriculation at the end of 1981. The group as a whole were almost equally divided between English and Afrikaans speaking students, while the 1981 matriculants were predominantly (84%) Afrikaans speaking. The average matriculation symbol for the 1981 matriculants was a C, with a D average in Science.

In viewing the performance of these students on the test material discussed above, it should always be borne in mind that the students who took part generally come from a socio-economically depressed background, and that their senior years at school were profoundly affected by the turbulent events of 1980 and 1981, when wholesale boycotts disrupted the school activities for protracted periods. Further, as indicated by the report of the de Lange Commission [4], some 70% of the Science and Mathematics teachers in Coloured Schools do not have the minimum qualification required to teach these subjects. These facts, coupled with the high first-year failure and attrition rate experienced at the University of the Western Cape underline the relevance of a bridging program, where even a small measure of success is a large step in the right direction.

6. Performance of first year students on the test materials:

The evaluation of the academic preparedness of the 1982 cohort of 1st year chemistry students revealed what can only be described as an appalling lack of readiness to attempt the rigours of a traditional first year university chemistry course. In total, 177 students signed on at various times in the three-weeks period, and attempted a total of 3973 instructional objectives. Of these, only 387 or 9,74% were mastered. No special aptitude for a particular section of the matric syllabus was demonstrated.

The performance of the students who wrote the matriculation examination in 1981 is analyzed in Table. 1. Their performance, (expressed as the percentage instructional objectives mastered) is lower (7,92%) than for the group as a whole. Not unexpectedly, the English-speaking students did better (10,9%) than the Afrikaans-speaking students (7,4%), this difference being explained by the language problem experienced by the latter students. The matriculation symbol for Science (Higher Grade) showed some correlation with their performance: the higher the symbol, the better their performance, (Table 2).

TABLE 1

Student sample (N = total in sample)	Objectives attempted	Objectives mastered	%
All participants (N = 177)	3973	387	9,7
All 1981 matriculants (N = 99)	2449	194	7,9
English speaking 1981 matriculants (N = 16)	386	42	10,9
Afrikaans speaking 1981 matriculants (N = 83)	2063	152	7,4

TABLE 2

Science HG symbol of 1981 matriculants (N = number who attained relevant symbol)	% Objectives mastered
A (N = 0)	-
B (N = 7)	11,8
C (N = 22)	11,3
D (N = 28)	7,3
E (N = 22)	6,6

7. Response of students to the Chemistry test materials:

A detailed questionnaire was filled in by 190 students, about equally divided among the two language groups. The responses demonstrated inter alia that

- 7.1 the test material was not considered easy.
- 7.2 the students found it useful to take the test before being assigned to specific lessons.
- 7.3 complete testing is considered important and necessary.
- 7.4 no clear opinion was formed as to the desirability of shorter tests on more fundamental topics.
- 7.5 students appreciated the importance of studying those topics in which they did not demonstrate mastery.
- 7.6 students felt they had learned something from the tests since PLATO gave them the correct answer to each test question.
- 7.7 students gained confidence in the subjects as a result of the "bridging activity".
- 7.8 students have been helped to understand what is expected of them in their first-year chemistry.
- 7.9 students desire to be retested after exposure to remedial material.

8. Attitude of students to the science and mathematics bridging program:

From the responses of 211 students who filled in a questionnaire, it transpired that

- 8.1 students were helped by the three-week bridging activities.
- 8.2 three-weeks appears to be about an optimum time-span.
- 8.3 students felt that the material learned on PLATO will be needed as background to the courses to be taken during the academic year.
- 8.4 students agreed that the program was organized with a view to help them obtain better results.

It is considered essential that any bridging program aimed at reducing the gap between school and university should have the support of the participating students. The attitude of the UWC students in this respect is thus most encouraging.

9. Attitudes of students to PLATO:

For all the students who participated in the program, it was their first exposure to CBE. How did they react to this highly sophisticated approach, and how long did they take to adapt to the use of the keyboard and touch-panel? The responses to a questionnaire (211 students) can be regarded as an overwhelming vote of confidence in the system, and augurs extremely well for the future of CBE at South African Universities. From the responses it can be deduced that

- 9.1 The students like to work on PLATO. Specific comments were elicited which emphasized the benefits of being able to work at one's own pace, to make mistakes in privacy, to enjoy the small triumphs of scoring against the machine, and to be patiently helped no matter how many mistakes were made.
- 9.2 Considerable irritation can be avoided by enforcing a rigid schedule of access to the terminals. A recurring negative comment was that students found terminals occupied when they should by rights have had access. This resulted in crowding of the terminal rooms, and invasion of the privacy of those working.
- 9.3 Students were particularly appreciative of the feedback obtained when making mistakes, and were very critical of the material where such feedbacks were absent, scanty or vague. Lesson designers please note!
- 9.4 The language problem is a very real one, and any large-scale implementation of CBE in South Africa must aim for a bilingual audience.
- 9.5 The introductory on-line material which was presented was adequate. It means in practice that the totally inexperienced user can interact usefully with the PLATO system after about 30 minutes introduction! It is essential that trained staff be present in the critical first session, but most students manage quite well on their own.

10. Management of large groups on the PLATO Learning Management system:

The three-weeks bridging program was not only of use to the students, but those of us closely connected with the project gained considerable experience in the management of large groups of students on a limited number of terminals (60 terminals were available to about 250 students).

In particular, it was probably the first time that such large groups were handled by the PLM system, which performed exceptionally well. The following must be considered as prerequisites for a successful operation on a large scale.

- 10.1 All testing materials must be organized well in advance and put through a "field trial" by an experienced staff member signed on as a student. He must undergo the same experiences that students will later experience. If necessary, modify the curriculum, course and module introductions in such a way as to prepare the students for subsequent displays.
- 10.2 Assistants should be trained to help students select some critical options if they are in need of help. All systems-generated messages are in terse "American-English", and Afrikaans-speaking students may have difficulties initially.
- 10.3 The data collection and record-keeping facilities should also be subjected to field trials well ahead of time. If data files are kept, it is well to bear in mind that these fill up very fast, and overflow may lead to loss of data. This is very important if an analysis of the response to test items is being attempted.
- 10.4 As many student names as possible should be entered in the group rosters before the start of the on-line experience. Thus it is essential that the university administration supplies accurate name-lists as early as possible. In our case, over 85% of the participants were correctly enrolled in the appropriate groups before going on-line, and late arrivals could readily be handled.
- 10.5 A lecture explaining the purpose of the program should be considered as being essential. In the present program, this was carried out immediately prior to going on-line, and use was made of this opportunity to explain sign-on procedures and scheduling.
- 10.6 A day to day check of the record provided by the PLM system should be kept, so that students who have finished testing may be put onto remedial material with a minimum of delay.

11. Conclusion

On the basis of the foregoing, we believe that a bridging program aimed at reducing the gap between School and University can be successfully carried out using computer based education. It is obvious however that the report presented here is incomplete, as the eventual outcome of the whole programme is not yet known. No bridging programme can be considered a success unless there is a significant improvement in the number of students who make a success of their first year at University. In the case at hand, the programme must be considered as an on-going process, and the performance of the students will be carefully monitored throughout the year. We trust however that students will benefit from the programme, as the intensive revision process which took place can only be beneficial in the long term.

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Note:

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PLATO-BASED TEACHER EDUCATION IN KWAZULU

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ABSTRACT

This paper reports on the early stages of a computer-based teacher education programme which is being developed in an impoverished and underprivileged part of Southern Africa.

The typical educational problems confronting developing countries are brought into focus by reference to needs experienced in Latin America and the Caribbean. Against this background the problems of the teacher education system in KwaZulu are analysed and a long-term plan for their solution is discussed. A brief account is given of some features of the PLATO system which has been selected as a means of revitalising teacher training. The first results are reported from a pilot study which is being undertaken in one of the colleges, and an outline is given of some interesting challenges which now face educationalists working on the project.

PLATO-BASED TEACHER EDUCATION IN KWAZULU

DONALD E. LOMAX

1. EDUCATIONAL NEEDS IN DEVELOPING COUNTRIES

"The Regional Conference of Ministers of Education and Those Responsible for Economic Planning of Member States in Latin America and the Caribbean" was convened by UNESCO in December 1979 and took place in Mexico City. The Conference acknowledged the consistent efforts which had been made by countries within the region during the past decade to develop their education systems and to improve the processes and content of education. It was recognised, however, that urgent problems remained such as the extreme poverty of many population groups, low enrolment rates within some education systems, a high drop-out rate in the schools, and the existence of a high proportion of illiterates within the adult population. It was also apparent that educational systems, processes and content were often inappropriate for the intended population groups and that some heavily centralised administrations failed to match their educational provisions with the cultural and economic development of their countries. Amongst a number of significant resolutions which were adopted by the Conference were the following (1) :

That a developed nation is one whose people are well-informed, cultured, efficient, productive, responsible and possess a sense of solidarity;

That no country can extend its development beyond the stage reached by its education;

That development is measured not merely by the goods or resources that a community can command, but essentially by the quality of the individuals who produce or use them;

That education is an essential tool for the release of man's highest potential to create a just and balanced society;

That the success that is sought in transforming curricula will depend on how such transformations interact with the specific needs, interests and problems of the social groups of the community;

That education, without prejudice to its universal scope, must essentially promote knowledge of the realities of the country and neighbouring countries as objectively as possible if the past is to be retrieved, substance to be given to the present, and guidelines to be laid down for the future;

That the training of people who are capable of accepting the implications of their own culture and of building scientific progress into it, is essential if they are to create, develop and adapt appropriate technologies;

That budgets for education should be steadily increased until not less than 7 or 8 per cent of the gross national product is allocated;

That all available means, ranging from the school and the communication media to natural resources, should be employed in a special effort to transform curricula to make them more relevant to the needs of under privileged groups;

That measures should be adopted for the renovation of teacher training systems;

That teachers should be assisted in economic and social terms by creating working conditions which will ensure that they enjoy a position in keeping with their social importance and professional dignity.

Although these resolutions referred to conditions in Latin America and the Caribbean, they have significance for the developing world in general and for Southern Africa in particular. The essential role assigned to education systems in plans for national growth, the vital contribution required from teachers, the recognition that teacher training is inadequate, and the acknowledgement that modern technology should contribute to training processes, are points of important emphasis.

It has been calculated that the provision of universal primary education by 1985 in the three regions of Asia, Latin America and Africa would require at least 12 million teachers, which is 3 million more than existed in 1977. The problem is equally serious in the secondary sector. It is therefore likely that the teacher recruitment and training crisis will remain acute in many developing countries for the foreseeable future. If teacher training needs are neglected, then the remaining years of this century will suffer the inadequacies of a major profession ill-equipped to cope with the profound transformations which will certainly affect social, economic and political processes (2).

2. INNOVATION IN EDUCATION

It sometimes seems that whilst the rest of society changes, the secluded provinces of education struggle to remain the same. However, those who work within education systems may respond positively to change, reject it, become its victims, or even promote it. If teacher education programmes are well-planned and properly financed, then it may be expected, with some optimism that the profession will respond positively to future challenges and perhaps become a creative innovative force (3). If teachers are indeed to play an active part in the complex process by which educational innovations are created, the teacher training systems must be more closely associated with educational research (4, 5, 6), curriculum design (7, 8), and with the emergence of new educational technology (9, 10, 11).

The content and process of preservice teacher education have already been subjected to vigorous revision in many countries and this process may be expected to continue on a wider scale in the future. Until recent times the major financial investment has been in preservice training. It has, however, become increasingly obvious that there is a need to provide inservice teachers with further continual training if they are to be expected to introduce new methods, curricula and technological innovations into education systems. It is vital that inservice teachers should play a significant role in educational innovation. Teacher training institutions must therefore see themselves as leaders of educational reform so that the teachers they train emerge as agents of change. The training process must embrace both preservice and inservice programmes and thereby facilitate the continuous renewal of the education system (12).

The problems of introducing educational innovations must be faced essentially at the local level. A rigid central bureaucracy cannot

impose meaningful innovations upon teachers. Those who seek to innovate must try to work with teachers and to try to create a supportive administrative and professional climate. If there is to be effective change at the grass-roots level then the voluntary participation of teachers in new ventures is essential (13).

The last decade brought changes in educational methods and attitudes in many countries. The technological explosion brought developments for which teachers had not been prepared by their initial training and the pace of change was uncomfortable in many areas of life and learning (14). In the age of communications satellites, concern for educational problems has become worldwide. Many emerging nations aim for developed education systems and look to the older countries for models upon which to base their own education and training programmes. Whilst it will be helpful for the new countries to take the best elements from these older models, it will be important to avoid the simple copying of those traditional forms which have already lost their vigour (15). Although educational programmes which are imported from the older countries have important contributions to make, the developing nations must build their education systems upon the basis of the values, needs and aspirations of local communities (16).

3. EDUCATIONAL NEEDS AND INNOVATION IN KWAZULU

Most of KwaZulu consists of traditional rural tribal areas where a subsistence agriculture is practised, but other sections constitute parts of metropolitan regions carrying substantial populations at urban densities, whose residents work in complex and sophisticated industrial and commercial organisations.

The problems of KwaZulu are in many ways symptomatic of those found throughout the vast continent of Africa, Latin America and the Caribbean. As an under-developed region KwaZulu lacks the material and human resources necessary for the creation of that infrastructure upon which a healthy society may be built. A major weakness in the present social fabric is the inadequate supply of trained and educated manpower. It seems certain that a major contribution to the social, economic and political development of the region would be made if the education system were re-vitalised and expanded.

The KwaZulu Government is determined that by means of education and training, the full potential of its nation will eventually be realised. The Government and its people seek to achieve impressive growth targets at national, regional and local levels. It is certain that these goals can only be attained by a trained and educated people. To produce such a population, an efficient and effective education system must be created. At the centre of this striving for greater learning, there must be a body of capable teachers. These teachers, upon whom such heavy responsibilities rest, must have the opportunity to profit from the best professional training that can be devised.

Unfortunately, the teacher training colleges in KwaZulu follow a well established historical pattern in being relatively low status institutions at this early stage of their growth, which must recruit their students from impoverished secondary schools. It is upon this shaky school base that KwaZulu has established its seven teacher training colleges, which, like most other colleges of their kind in the world, are imperfect.

There can be no doubt that it will be some time before they attain any measure of positive comparison with the élitist institutions such as universities.

That they have advanced so far, is greatly to the credit of a devoted group of serious professionals who have laboured to lead the way towards a future with hope. The colleges are almost invariably situated in scenically attractive locations but not always, for historical reasons, in places which make the most sense in terms of population distribution or educational need.

By third world standards, the buildings are excellent; by the standards of the developed world they are barely adequate. The colleges' lack of certain basic resources, such as libraries and science laboratories, is so crippling as to render their task almost insurmountable. The absence of books in some instances, almost projects the observer back into pre-printing press times. It is as if the hand of modern technology had yet to rest its energising fingers on the outmoded existing college teaching process.

The Principals of the colleges, although varying in experience and personal background, are without exception forward-looking men. Some of them have trusted deputies. They are backed by a small number of excellent staff, and a larger group of determined but inexperienced teachers. They must also work with a minority of less competent staff, who in terms of experience, academic qualifications, training and attitudes, are unfitted to face the problems which confront them. This team of teacher educators works with a curriculum which has a pattern familiar to teacher trainers with a historical knowledge of curriculum development in other places. There are many subjects, or rather parts of subjects, which are seldom treated in depth, and which can never coalesce into an integrated curriculum. It is difficult for the teacher educators to unify the material but there is the traditional, unfortunate, and almost unexamined assumption that where the teachers have failed, the students may, by some adroit undefined process, succeed.

The students tend to be the product of impoverished home backgrounds and ill-equipped schools. These schools, lacking in both physical and human resources, fail badly to give the students the necessary educational background, and worse, inculcate in their charges negative learning habits, widely separated from the love of learning for its own sake. Students are heavily committed upon entry to the colleges to rote learning, and find little in their subsequent college experience to persuade them to abandon this inappropriate learning style. The students tend to accept the conditions of learning with depressing passivity.

The methods of teaching in the colleges are rigid and formal. There is a strong commitment to the routine, passive, inflexible, large-group lecture situation. Multi-media presentations are almost unknown, and lecturers sometimes use ill-prepared materials. Principals and staff are theoretically committed to creative, active, individualised, problem-solving approaches, but the pressures of the teaching situation are such that it seems difficult to translate these ideals into practice. No matter how inspired the staff might become, severe restrictions would be placed upon the products of their efforts by the quality of the student intake. As in some other parts of the world, the teacher training colleges do not attract the academically most able pupils.

The KwaZulu Government is aware of these problems and of the need to find innovative solutions. It is recognised that the last decades have witnessed an unprecedented world-wide expansion of educational opportunities. It is clear that this expansion will demand an increase in the quality and quantity of the teaching force in KwaZulu, which may be achieved by extending the present provisions for personal and vocational education. Some of the literature in teacher education suggests that the "professional development" and "personal development" of teachers are distinguishable processes. Whilst it is true that much research still remains to be done in this area, it may be argued that these processes are one and the same (17). The KwaZulu Colleges, therefore, should be concerned not only with the training of teachers in a narrow range of skills but also with their wider personal education. Whilst there must be proper concern for increasing the size of the teaching profession, emphasis must also be given to creating more meaningful training procedures (18).

During 1980, a rigorous study, undertaken by Kirkpatrick Educational Consultants, of the existing teacher education system in KwaZulu, indicated that the vicious cycle of poor home conditions, poor schools, poor teachers, poorly trained people and poor work opportunities, might be radically changed by planned intervention at the teacher education stage. The evidence gathered suggested that no traditional form of remedy may be possible in the time available. Indeed, it seems probable that even vigorous investment in the traditional education system will fail to provide enough buildings and educational materials to even maintain present standards, given the explosive growth of the demand for education and training. As far as the supply of college staff is concerned, the position seems likely to deteriorate, as the demand for skilled labour in all sectors of the economy increases, leaving the colleges unable to compete for the best qualified professionals.

It is in some ways curious that a traditional solution to these difficult problems should be even contemplated, for this is an age in which educational technology promises to change educational systems radically, and for the better. In many countries the trends are now towards diversification, individualisation, and personalisation of learning. The speed at which this movement will advance is likely to depend, however, upon the success we have in adapting our initial and in-service teacher education systems, to enable them to overcome that professional inertia which weighs against all innovations (19). In facing these formidable challenges, we are encouraged by the emergence of a new educational technology (20, 21, 22, 23, 24).

This technology provides a systematic way of designing, carrying out, and evaluating, the total process of learning and teaching in terms of objectives which are based upon research in human learning. The aim is to produce efficient and effective learning by a systematic and humane process. Educational technology, therefore, is not simply concerned with audio-visual aids, teaching machines, computers, or other teaching devices. It is not to be confused with electronic gadgets, for it is wide as education itself. It is concerned with the design and evaluation of curricula and learning environments, and with the problems of educational implementation and renovation. Essentially, educational technology is a rational, problem-solving approach to education, a way of thinking sceptically and systematically about learning and teaching.

Amongst the most important developments associated with this rational, problem-solving approach to education is the emergence during the last twenty years of computer-based education. The state of the art in this field is represented by the Control Data PLATO System, a fact convincingly demonstrated by a rigorous study recently carried out by the Educational Research Centre at the University of Leyden in the Netherlands (25). The research report assessed four leading computer-based education systems on 14 important aspects of performance. The PLATO System was placed first on 12 of the assessment scales and was rated second on the other 2. The verdict of this review was that "The PLATO System is clearly the best". After careful study of the problems which had to be faced and of the available solutions, the KwaZulu Department of Education and Culture invited Control Data to co-operate in the production of a plan for the design, development and implementation of PLATO-based teacher education programmes.

4. THE PLATO SYSTEM

The PLATO System (26, 27, 28) utilises one of the most powerful mainframe computers available, a graphics display terminal with touch sensitive screen, a keyboard, operating system software, and interlinking communications equipment. PLATO is based upon over twenty years of intensive research in some of the world's leading universities and has thrived upon an investment in its development of over nine hundred million dollars. It has thousands of hours of courses in over a hundred subject areas and has a sophisticated education management system which integrates a wide range of materials, teaching techniques and evaluation procedures.

PLATO's uniqueness as a computer-based education system derives from the many different possibilities it offers for interaction between the computer and the student, between the computer and the author, and between the computer and the teacher or administrator. The system also handles a variety of teaching modes with considerable finesse. Another of the important features of PLATO as a computer-aided instruction system is that it puts the student in control of the pace at which the lesson proceeds. Any segment of study can be repeated as often as the learner desires. Thus lessons can be studied slowly or rapidly depending on the prior skills or inclination of the student. This proves to be advantageous for students of many ability levels for it means that learning may be geared to the needs of the average student or the slow student or the superior student. PLATO thus meets the student at his own level and proceeds with him at a pace and in a fashion suitable to his individual needs.

The communication between PLATO and the learner takes place in normal language. The vocabulary used is the everyday language to which the student is accustomed. Many lessons allow the learner to be addressed by his first name. In addition, both the student and the teacher may leave notes for one another when there are problems requiring personal attention. The teacher is also able to leave messages for the whole class. Students and teachers may hold direct conversations through the terminal, whether they be within the same building, in different cities, or even in different countries.

On those occasions when it is helpful for the teacher to monitor a student's progress through a lesson, noting the time taken on the various parts, the answers given, and the problems that arise, the

teacher is able to link into the student's lesson regardless of the physical location of the terminals. Everything being shown on a student's terminal is also displayed on the instructor's screen. In these circumstances, the student is also provided with a note on his screen telling him that he is being monitored.

Although these brief notes may serve to provide only a superficial account of a powerful and complex system, it will be obvious that educators in KwaZulu now have some interesting opportunities to attack persistent problems with new weapons.

5. THE DEVELOPMENT PLAN

The development plan for the teacher education system in KwaZulu, provides for the establishment of thirty-two terminal PLATO Learning Centres in every college and the provision of an eight terminal Administrative Centre in the Department of Education and Culture.

A four stage development plan is suggested as a flexible, pragmatic and practicable programme for the creation of a computer-based teacher-education system. At every stage of development close liaison is maintained between Control Data consultants, college staff, Government administrators, and departmental advisors.

There is insufficient space in this short paper to give a detailed description of all the studies, activities and problems which characterize the stages which are labelled; definition, design, establishment and institutionalisation. The definition stage is essentially devoted to a broad analysis of problems and the production of a draft long-term plan for solutions. The design stage is devoted to further analysis and pilot studies. A major output is a detailed and dynamic project plan. The third stage sees the firm establishment of computer-based education throughout the teacher education system. During the final years of the plan the computer-based system becomes institutionalised and operates as an autonomous system with creative capabilities which may serve the entire community.

Within the broad plan individual colleges will develop through a sequence of four phases.

PHASE 1

Introduction to computer-based education and PLATO for college staff and their students, by means of a variety of procedures. These will include : visits to Control Data Learning Centres and to Learning Centres in other educational institutions; conferences for College Principals; demonstrations for key college staff and student leaders; workshops conducted by visiting consultants; the establishment of curriculum review committees; consultations with academic planners; installation of the PLATO Centre; and the training of a Learning Centre Administrator.

PHASE II

A one-year trial of the system. During this period a well-qualified consultant will be attached to the College. It will be his task : to create a total educational environment, within which PLATO will be integrated in a multi-media educational programme; to train staff in

the use of PLATO; to lead curriculum design teams within the college and to contribute to the development of such teams throughout the KwaZulu system.

PHASE III

For a further two years a consultant will be attached to the college with the goal of providing a mature PLATO system at the end of this period. The consultant will : train relevant staff; lead curriculum design teams; and contribute to the total KwaZulu programme in all the institutions involved. The skills of college staff will be expected to widen and deepen during this phase. The curriculum will also be extended to provide opportunities for the implementation of PLATO Learning Management.

PHASE IV

It is envisaged that, by the time that this phase starts, each college will have attained maturity in the employment of its PLATO system, and that a measure of integration will also have been achieved with other institutions in KwaZulu. Emphasis will be placed upon the emergence of a fully integrated KwaZulu model within which all institutions will be mutually supportive. In this final phase, the institutions should all be capable of independent operation. However, Control Data will continue to provide consultants who will lead specific project teams which will embrace all the institutions integrated within the model. An example of this kind of project is the design of microteaching programmes to which all institutions would contribute under the leadership of well-qualified external consultants.

6. THE PILOT PROJECT

Madadeni College was chosen as the location for the pilot study and has successfully completed Phase I of the development programme. Phase II began in January 1982 and Phase III will begin in January 1983. By 1985 it is expected that the College will have gained sufficient experience and expertise to enable it to make a strong contribution within all sectors of the KwaZulu Education System.

The PLATO centre at Madadeni has proved to be an enormous instant success, and is widely acclaimed as a great educational advance throughout KwaZulu. Every terminal is occupied from early morning until late evening by enthusiastic students. The existing PLATO curricula in English Language, Mathematics and Science are the first major contributions to College teaching, but in subsequent years new courses in teaching science and in the professional educational disciplines will be developed. The present enthusiasm for computer-based education is so contagious within Madadeni College and also within the KwaZulu Department of Education and Culture that requests are already being received for the extension of the project beyond the colleges, into the field of inservice teacher training. News of the project has resulted in a two hundred per cent increase in student applications for places at Madadeni.

In the absence of concrete evidence to the contrary, it is sometimes assumed that Black students will react negatively to the introduction of educational technology into their learning environment. The results of attitude studies carried out at Madadeni College, however, demonstrate strong support for the PLATO System. The attitude tests in question are administered and scored by PLATO within two minutes. A printed copy of

the statistical analysis of results is available almost immediately.

The results of a study undertaken after PLATO had been in operation at Madadeni College for two months showed that 96% of the students were pleased that their College was the first to receive PLATO. Similar percentages of students felt that : the PLATO Learning Centre was a pleasant place in which to work; PLATO made learning enjoyable; most of their fellow students enjoyed their PLATO studies; most College teachers were interested in PLATO lessons; the PLATO lessons which they had studied would help them to become better teachers; and that PLATO lessons would help them in their academic studies. Over 90% of the students supported the decision to choose Mathematics, Science and English as areas of priority in PLATO studies. Some 88% of the students indicated that they would like to study additional lower level English lessons in the belief that this study revision would benefit all their college work. Some 77% of the students asked for an opportunity to use PLATO for remedial work in Mathematics. Over 97% of the students asked for future opportunities to study a wider range of subjects on PLATO, and wished to see the system as an integral part of the College curriculum. It was quite clear that students were eager to use PLATO at every opportunity. Some 95% of the students asked for PLATO to be available during evenings and weekends. At the present time the PLATO Centre is in use from 5 a.m. until midnight, and students are studying not only the set curriculum but also a range of other subjects for their personal interest and pleasure.

There have been several interesting side effects following the introduction of PLATO. As news of the exciting new learning opportunity spread around the nearby town, local high school students began to come to the College and impersonated students in order to gain access to the PLATO Centre. Nurses from a nearby hospital, lecturers from the technical college and various local industrialists have all visited the Centre. One university in the region which sent several delegations to view the project, eventually decided to mount something of a mass invasion by sending a party of 62 educationists, comprising 6 members of staff and 56 senior students for a day's study. The College appears to have taken this newly acquired fame in its stride. Morale, according to the College Rector, has never been higher!

7. CHALLENGES FOR TODAY

The kind of vigorous initiative which is now taking place in KwaZulu inevitably raises a number of questions. Most of these questions have already been asked in other places, at different times. However, they must now be faced in the local context by the professionals who are on the spot.

One of the first areas of concern is the teacher education curriculum which appears to have been accepted without question by most teachers in the past. Broadly defined the curriculum encompasses the totality of experiences which influence students as they move through the educational programme (29). Unfortunately on many occasions curriculum development has been narrowed to mean just the production or modification of a single course. In the KwaZulu experiment it will be necessary to concentrate energies upon the creation of a total learning environment which will be multidisciplinary and multimedia in character. The PLATO system will be fully integrated within this environment and is likely to be assigned a significant managerial role.

In some disciplines, such as Mathematics, PLATO will certainly provide excellent computer-assisted instruction. The analysis and synthesis of many studies in this field point to a significant enhancement of learning in various instructional environments when computer-assisted instruction is employed (30, 31). It is also encouraging to find that progress is being made in linking Mathematics teacher education to such educational disciplines as Philosophy, Sociology, Educational Psychology, History and Curriculum Studies (32, 33). However, more research is needed into the instructional psychology of planning and authoring computer-assisted lessons (34, 35). The Colleges of Education must in fact become much more familiar with the impact which computers are making, not only in industry and commerce, but also in the schools where computers are becoming familiar parts of the environment. In France, for example, the study of Informatics has been introduced into the secondary school through established disciplines. This development has created a need for further teacher training (36). This kind of accommodation which schools occasionally make in response to pressures from society, has sometimes had negative consequences in that the curriculum has become a "potpourri of accretions" (37). It may be argued that the school is unable to resist these external pressures because of uncertainty which has roots in inadequate professional training. The basic need, the argument continues, is for greater accountability amongst teacher educators.

The enormous power of the computer in terms of speed, data collection and analysis, and the production of records, opens up new possibilities for the extension of Performance-based Teacher Education models. Accountability may please administrators and taxpayers but it may be threatening to teacher educators. The Performance-based movement has excited some strong support (38, 39), but opponents have pointed out that it may be criticized from a philosophical point of view for its narrow conception of teaching and for its very limited research base (40, 41). In the KwaZulu setting the entry of the computer is likely to increase levels of accountability, producing some discomfort in the short-term, and increased effectiveness in the mid-term.

A basic aim of the KwaZulu project is to develop a model computer-based teacher education system which may be replicated in other parts of Africa, and perhaps even in other developing countries. At this stage it seems certain that many positive achievements are possible, and that these advances may be transferred to other contexts. Given the resources, it should be possible to create PLATO-managed micro-teaching programmes for example (42, 43). Other forms of in-college laboratory teaching experience, such as reflective teaching (44) or programmes using protocol materials (45) might be managed in the same way. Teacher educators in KwaZulu thus have an excellent professional opportunity not only to respond meaningfully to real local needs, but also to achieve international distinction by assuming a position of academic leadership. However, simulation studies will need to be developed with care as doubts exist about the efficacy of simulation as an instructional strategy (46). It must also be recognised that a vast amount of research will be necessary if an effective teacher education model is to be produced (47, 48, 49, 50).

The initial success of the KwaZulu project has produced a vigorous momentum which promises to extend the influence of PLATO beyond College boundaries. Already a study of inservice teacher education has been launched in recognition of the fact that "the continually learning teacher is as important as the continually learning child" (51).

The study will consider the special needs of the adult learner (52) and investigate the possibility of establishing teachers' centres in KwaZulu (53).

The KwaZulu teacher education programme will be strongly supported by able professionals who believe that computers offer great promise of future benefits for education. Not everyone will see the necessity for developing a theory of instruction. However, as Harold Mitzel has pointed out (54) a well-articulated theory provides a guide for the evaluation of the product by helping to define criteria. Too often in education mere opinion or historical inertia moulds behaviour, when what is required is a theory of instruction to provide a scientific framework within which educators may operate. We do not yet have the necessary theory, but we must work consistently to build it.

It is now over a quarter of a century since B.F. Skinner wrote :

"We are on the threshold of an exciting and revolutionary period, in which the scientific study of man will be put to work in man's best interests. Education must play its part. It must accept that a sweeping revision of educational practices is possible and inevitable." (55).

An exciting period has arrived in KwaZulu. Education must play its part.

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COMPUTERS IN ENGINEERING

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ABSTRACT

This paper describes how computing facilities in the Engineering Faculty have expanded over the past ten years and then explains how this expansion has lead to changes in curriculum and approach to teaching and examinations. Some experiences are described which illustrate both incorrect and correct decisions relating to computers. It is hoped that these illustrations will assist others, who are developing computer facilities, to make correct decisions.

THE COST OF PLATO[®] IN A UNIVERSITY ENVIRONMENT

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ABSTRACT

The University of Delaware has been operating its own PLATO system since 1978. Both the capital costs of acquiring the system and the ongoing costs of running it are exposed and analyzed. It is shown how the design philosophy of the PLATO system can allow a university to substantially reduce the hourly cost of using PLATO below commercial rates. The actual cost of using PLATO at Delaware is compared to past projections of what the cost would be. Continuing efforts to reduce the cost of using PLATO are described. It is shown how the cost of PLATO hardware is continually decreasing, and the influence of micro PLATO on cost projections is discussed. The issue of cost effectiveness is addressed in the context of dollars spent and value received.

Introduction

Twelve years ago, Alpert and Bitzer (1) estimated the operating costs of their newly implemented PLATO IV system. Based on assumptions regarding the costs of central system hardware, courseware development, student learning stations, central management services, and communications channels, they projected that the cost of delivering one hour of instruction would be in the range of thirty-four to sixty-eight cents. Five years ago, Kearsley (2) reported that if one were to lease a single terminal from the Control Data Corporation, the company that sells PLATO, the cost would be \$1,200 per month per terminal, which, when divided by the same number of hours of student use assumed by Alpert and Bitzer (2,000 hours per terminal per year), yields an hourly usage fee of \$7.20. Kearsley noted that even when adjusted for inflation, this cost is far in excess of the estimates made by Alpert and Bitzer.

A principal reason for the difference between Alpert and Bitzer's estimate and the price quoted by Kearsley is that the original estimate assumed a university setting for the operation of the PLATO mainframe. In a university environment, it is possible to reduce the hourly cost of PLATO substantially below what it costs to lease single terminals on a commercial basis. It will be the purpose of this article to show how the University of Delaware has taken advantage of the design philosophy of the PLATO system to achieve such a reduction. Delaware's budget for computer-based instruction will be fully exposed, and it will be shown how a CBI budget is accounted for in a university environment. It will be seen that although Delaware has substantially reduced the cost of PLATO below the prices that Kearsley quoted, the actual cost of using PLATO at Delaware is still much higher than Alpert and Bitzer projected. The reasons why it is higher are discussed, and continuing efforts to reduce the cost of using PLATO in a university environment are described.

The discussion is presented in six main sections. First, the concept of critical mass is introduced. It is explained how the PLATO system was designed for large numbers of users, and it is shown how the unit cost of PLATO decreases as the number of users increases. Second, Delaware's capital investment in PLATO is exposed. All of the central site hardware purchased since the acquisition of the Delaware PLATO mainframe in 1978 is listed along with prices paid and sources of funding. Third, ongoing expenses and revenues that have been experienced since the acquisition of the mainframe are discussed in the categories of university funds, contracted services, and grants. Fourth, comparisons of the actual cost of using PLATO on the Delaware PLATO system are made to past projections of what the present-day cost of using PLATO would be. Fifth, it is shown how the cost of PLATO hardware is continually decreasing, and the possible future impact of micro PLATO on cost projections is discussed. Finally, the article concludes by addressing the issue of cost effectiveness in the context of dollars spent and value received.

Critical Mass and the Per-Terminal Capital Cost of PLATO

The PLATO system is the state-of-the-art in computer-based instruction (CBI). It provides a rich CBI environment with on-line aids for authors, instructors, and students. It supports a student learning station that has high-resolution graphics, student control keys, touch input, and external connectors to which videodisc players, sound generators, slide projectors, speech synthesizers, heart-rate monitors, electronic test equipment, pitch detectors, digitizers, printers, screen copiers, and other peripherals can be attached. The PLATO system is so fast that not only do student interactions with the computer appear to be instantaneous, but animations can also be done on the high resolution display. It requires a large computing resource to support these features, and this is what makes PLATO expensive.

The University of Delaware began using PLATO in the spring of 1975 when its first terminal was installed. This terminal was connected by means of a telephone line to a Control Data PLATO system in Minneapolis. In addition to leasing PLATO services on a commercial basis, the University also paid for the long distance telephone line. As the demand for PLATO services increased, the University gradually acquired more terminals. Each time a terminal was added, the Delaware PLATO budget increased by a fixed amount that included telephone costs and a PLATO service lease.

By the spring of 1978, the University of Delaware was operating 32 terminals on 8 long distance telephone lines, with four terminals multiplexed on each line. At this point the Delaware PLATO Project reached critical mass, the point at which it became cheaper for it to purchase its own PLATO system than to continue leasing services from remote systems. The benefit of reaching critical mass was that, with its own PLATO system, the University of Delaware could take advantage of the fact that as one adds terminals to a PLATO system, the per-terminal capital cost of the system goes down.

The reason why the per-terminal cost goes down as terminals are added is because of the unique architecture of the PLATO system. There are four main components in the system, namely, a central processing unit, extended memory, disk storage, and communications equipment. Each time a terminal is added to the system, a small amount of communications equipment must also be added. Additions of central processing, extended memory, and disk, on the other hand, are not automatically required for each new terminal. The amount of processing time, extended memory, and disk that is needed on a PLATO system depends not only upon the number of terminals that are connected to it, but also upon what is being done with those terminals.

If two students sign on to the PLATO system and request two different lessons, those lessons are transferred from their permanent storage location on disk into the extended memory where they reside while the students are using them. Since two different lessons are being used, they occupy two different portions of extended memory. On the other hand, if both students asked to use the same lesson, that lesson is only transferred once from disk to extended memory, and both students share the same exact portion of extended memory. If one thousand students ask for the same lesson, that lesson would occupy no more space in extended memory than if only one student were using it. The more sharing of lessons that occurs on a PLATO system, the more users it can support.

The Capital Investment in PLATO at Delaware

At the present time the Delaware PLATO system has 330 terminals connected to it. The average peak number of terminals active during prime time is 140. Half of the use of the system is students running PLATO lessons. 9,000 students taking 112 courses use the system each semester, and this diversity of courses coupled with the self-paced nature of computer-based learning results in a relatively small amount of sharing of lesson materials. On the average, when 100 students are taking lessons on the Delaware PLATO system, 50 lessons are in extended memory serving their needs. It has been estimated that if memory were in tight supply, strict scheduling could reduce this need to 30 different lessons.

With this characterization of the Delaware PLATO load, the history of the staging of hardware additions needed to support this load can be traced. It is important to note, however, that under different loads the number of users that can be supported at each stage varies. When the Delaware PLATO mainframe was purchased in March of 1978, there were 50 terminals connected to it. The original configuration consisted of a CYBER 173 single processor system with 500,000 words of extended memory plus miscellaneous communications and disk storage equipment. This served the University well until the number of users increased to 75. At that time, it became necessary to add memory, and another 500,000 word bank of extended memory was acquired. One million words of memory were added when the number of users reached 228. When the number of users grew to 300, the processing limit of the 173 single processor was reached, and a second processor was added, making the Delaware PLATO system a CYBER 174. A further addition of one million words of extended memory is planned for when the number of users reaches 450, and if the number of users exceeds 560, a second mainframe will be needed.

Table 1 shows the history of capital investments in the Delaware PLATO system. In addition to the major upgrades of extended memory and central processing discussed above, smaller additions of peripheral processing units, disk drives, tape drives, and communications equipment are included so that this table shows all of the capital expenditures that have been made to date. A distinction is also made as to whether internal University funds or revenues from contracts and grants were used to pay for the various system additions. Sources of funding will be further discussed in the next section of this article. PLATO terminals are not listed in table 1. The cost of terminals will be considered below when the hourly cost of using PLATO is calculated in the section that compares the costs of PLATO at Delaware to former cost projections.

TABLE 1
Capital Cost of the Delaware PLATO System

Install Date	System Component	Internal Funding	External Funding
3/78	Initial System (CYBER 173)	\$1,896,305	
11/78	Memory Upgrade		563,255
11/78	Disk Upgrade		148,400
6/79	Communications Upgrade		14,079
7/79	Peripheral Processor Upgrade		85,660
1/80	Peripheral Processor Upgrade	13,890	
1/80	Communications Upgrade	7,581	
3/80	Communications Upgrade	8,786	
6/80	Communications Upgrade		28,900
6/80	Tape Upgrade	103,500	
6/80	Communications Upgrade		17,328
8/80	Disk Upgrade	109,840	
9/80	Memory Upgrade		557,029
9/81	CYBER 174 Conversion		222,630
10/81	Communications Upgrade	7,460	
10/81	Communications Upgrade		17,328
	SUBTOTALS	2,147,362	1,654,609
	TOTAL INVESTMENT	\$3,801,971	

Figure 1 graphically portrays the staging of hardware additions that have been made to the Delaware PLATO system, showing how many users have been able to be supported at each stage. The declining cost curve shows how the per-terminal capital cost of the Delaware PLATO system has gone down as the number of users has increased. Today, with 330 terminals connected to the system, the per-terminal cost of central system hardware is \$11,521. A projected memory upgrade that will be made when the number of terminals reaches 450 has also been included. Ongoing expenses associated with these hardware additions are discussed in the next section of this article.

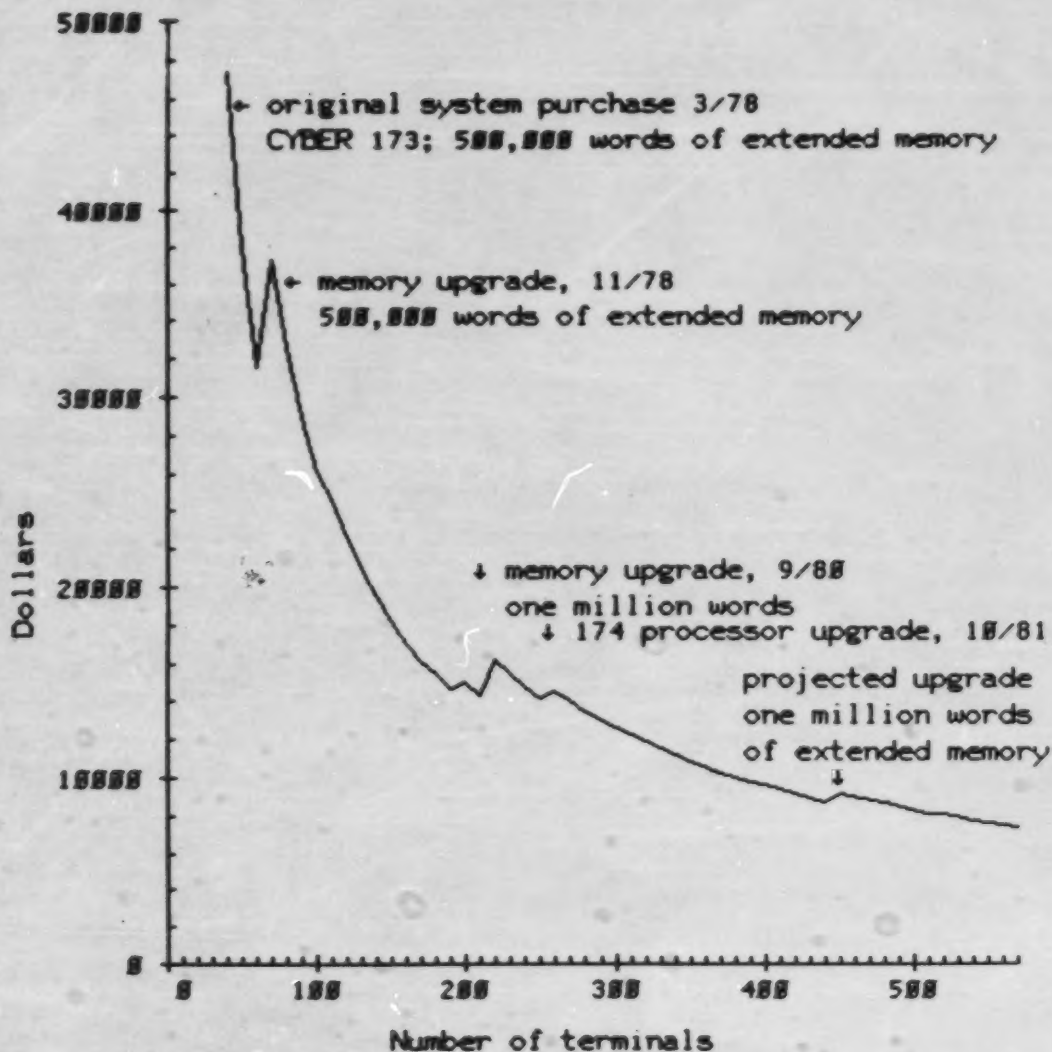


Figure 1. The Per-terminal Capital Costs of the Delaware PLATO System.

Ongoing Expenses and Revenues

There are three main components in Delaware's CBI budget. First, there is the hard-funded allocation of University funds that pays for the University's share of the PLATO system and for the development of Delaware PLATO lessons. Second, there are the expenses and revenues associated with outside contracts. Third, there are the expenses and revenues associated with grants. Each of these components is discussed in turn as follows.

1. University funds. It is beyond the scope of this article to trace the entire history of the development of Delaware's hard-funded budget for computer-based instruction. However, it will suffice to discuss the present state of this budget in 1981-82. During 1981-82, the University of Delaware's internal budget allocation for computer-based instruction is \$2,157,456. Of this amount, \$591,300 is going toward paying off the debt on the capital equipment listed above in table 1; \$208,599 is being used to purchase new PLATO terminals, peripherals, and microcomputers; \$563,428 is paying for PLATO operations, which include four services and systems personnel, two on-line consultants, hardware maintenance, and usage charges for software and courseware; \$726,549 is supporting a programming staff of 28 professionals and 43 students who are developing Delaware PLATO lessons; and \$67,580 is allocated for the operations of the University's CBI research center.

2. Outside contracts. There are two kinds of contracted CBI services available at the University of Delaware. These are PLATO ports and programming services. Since the installation of the Delaware PLATO system in 1978, the number of PLATO ports contracted by outside customers has grown to its current level of 141. Customers have also contracted with the University for the programming of customized courseware. In 1981-82 the University has seven customer courseware contracts.

3. Grants. The University has received a variety of CBI grants. These grants fall into two main categories, namely, courseware development and training. The courseware development grants are similar to the customer courseware contracts, with the main difference being that the materials programmed for customers are defined by customers, whereas the materials programmed under grants are defined by University faculty members. The many lessons programmed under contracts and grants have given Delaware a good feel for how much it costs to develop an hour of instruction on PLATO. A typical tutorial with good interaction costs \$4,000. This price covers 40 hours of design time during which a script is written by the designer and reviewed by the contractor and by the University's CBI quality control committee, 120 hours of programming time during which the designer spends an additional 15 hours monitoring development and specifying changes where needed, and 21 hours of revision time after the lesson has been tested by the contractors. Hourly costs for lesson development sometimes go as high as \$8,000 for a simulation and as low as \$2,500 for a lesson that does not require sophisticated judging or graphics.

Table 2 lists the grants that have been received since the installation of the Delaware PLATO mainframe in 1978. For each grant, the funding agency, subject, director, and dollar amount are given. The total amount of grants received since 1978 is \$1,672,536.

TABLE 2

CBI Grants Received by the University of Delaware Since 1978

Agency	Department	Director	Amount
NSF	Anthropology	Peter Roe	\$23,569
NSF	Biology	David Sheppard	23,233
NSF	Chemical Engineering	Stanley Sandler	24,969
NSF	Mathematics	Ron Wenger	248,987
NSF	Mathematics	Clifford Sloyer	204,865
NSF	Mathematics	Morris Brooks	13,416
NSF	Mathematics	Ron Wenger	23,320
NSF	Political Science	Richard Sylves	24,010
NSF	Psychology	James Hoffman	18,529
NSF	Summer Institute '79	Fred Hofstetter	30,156
NSF	Summer Institute '80	Fred Hofstetter	44,107
NSF	Summer Institute '81	Fred Hofstetter	49,967
NSF	Micro Institute	Fred Hofstetter	15,120
CDC	Counseling	Richard Sharf	225,000
CDC	Chemistry	Fred Hofstetter	259,000
CDC	Mathematics	Bonnie Sellar	170,000
NEH	Music	Fred Hofstetter	274,288
TOTAL			\$1,672,536

Table 3 shows how the University's contribution to Delaware's budget for computer-based instruction combines with expenses and revenues from contracts and grants to form an overall budget profile. Columns are provided that show budget figures for the years 78-79, 79-80, 80-81, and 81-82, so that some historical perspective on the development of the CBI budget at Delaware can be formed. It is interesting to note how the percentage of funds derived from outside contracts and grants has risen from 5% in 1978-79 to 42% in 1981-82.

TABLE 3

Summary of Budgets for 78-79, 79-80, 80-81, and 81-82

	78-79	79-80	80-81	81-82 ¹
University Contribution to the OCBI Budget	1,411,586	1,901,563	2,004,640	2,157,456
Expenses to Support Outside Contracts	0	5,926	107,799	519,596 ²
Expenses ³ to Support Outside Grants	35,218	35,837	163,719	487,646
Total OCBI Expenses	1,446,804	1,943,326	2,276,158	3,164,698
Revenue from Outside Contracts	31,394	243,062	484,904	716,042
Revenue ⁴ from Grants	46,604	49,841	225,050	619,007
Total Revenue	77,998	292,903	709,954	1,335,049
Percentage of Budget Offset by Revenue	5%	15%	31%	42%

¹ Expenses and revenues given in this column are current projections.

² This includes outright purchase of the 174 conversion listed above in table 1.

³ Direct costs for CBI grants.

⁴ Includes revenues derived from the indirect cost rate that the University negotiates with its external sponsors.

Comparing Costs of PLATO at Delaware to Former Cost Projections

The calculation of the annual per-terminal cost of running the Delaware PLATO system includes five cost factors. The first factor is capital equipment. The total capital outlay for central-site hardware is amortized over a seven-year period. The second cost factor is hardware maintenance. This includes both contracted maintenance services and on-call "premium" maintenance that is needed when the machine breaks down outside the period of normal maintenance. Third, usage charges are included, both for the use of PLATO and NOS software and for PLATO courseware. The fourth cost factor is operational and services staff. This includes operators, systems programmers, on-line consultants, and outside customer service representatives. The last cost factor is overhead. Overhead is figured at 23% of cost factors two, three, and four. Table 4 shows how the computation of these figures results in a total annual operational cost of \$1,259,204, which, when divided by the 330 terminals connected to the system, yields a per-terminal operational cost of \$3,816 per year.

TABLE 4

Calculation of the Annual Per-Terminal Cost
of Running the Delaware PLATO System

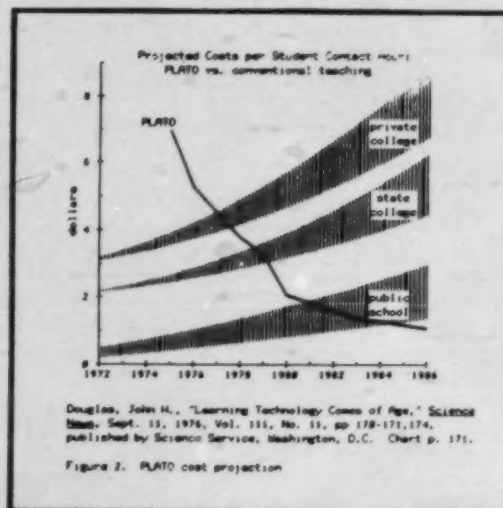
Cost Factor	Annual Cost
Capital Equipment (7-Year Amortization with Interest)	\$752,247
Hardware Maintenance (Contracted and Premium)	170,280
Software and Courseware Usage Charges	68,280
Personnel (Operations and Services Staff)	173,600
Overhead (23% of Cost Factors Two, Three, and Four)	94,797
TOTAL ANNUAL COST	\$1,259,204

\$1,259,204 Divided by 330 Yields a Per-Terminal Cost of \$3,816.

Dividing the \$3,816 annual per-terminal cost of using PLATO at Delaware by the 2,000 contact hour per terminal figure used by Alpert and Bitzer yields an hourly cost of \$1.91. This figure does not include the price of the PLATO terminal; nor does it include terminal maintenance or communications. The present price of an IST-1 PLATO terminal is \$2,900. Amortizing this cost over seven years would add \$414 to the annual per-terminal operating cost, or \$0.21 to the hourly cost. Annual terminal maintenance at \$456 adds \$0.23 to the hourly cost. The price of communications is more difficult to factor in, because it depends upon the distance of the terminals from the mainframe and the multiplexing strategy that is used. On the Delaware campus and within a local calling distance from the mainframe, the cost of communications averages about \$240 per year, adding another \$0.12 for a total hourly cost of \$2.47. It should be pointed out that not all of the 330 terminals connected to the Delaware PLATO system are used 2,000 hours per year. Terminals devoted to student use are used that much, but research and development terminals tend to be used less and have a correspondingly higher hourly cost.

In order to compare the \$2.47 hourly student-use cost of PLATO at Delaware to the \$0.34 to \$0.68 range estimated by Alpert and Bitzer, two adjustments need to be made to the latter figures. First, capital equipment at Delaware is amortized over seven years, whereas Alpert and Bitzer used five years. A seven-year amortization of their capital equipment figures yields an hourly cost of \$0.31 to \$0.65. Second, according to Delaware's Office of Institutional Research, a 1970 dollar adjusted for the inflation that has occurred between 1970 and 1982 would equal 2.39 times its face value. Multiplying the \$0.31 to \$0.65 range times 2.39 yields an adjusted range of \$0.74 to \$1.55.

The \$2.47 hourly cost at Delaware is within two times this adjusted range. Considering the fact that the number of users connected to the Delaware PLATO system is less than one-tenth of the 4,096 users that Alpert and Bitzer assumed in making their estimate, \$2.47 seems reasonable. It is interesting to compare the \$2.47 figure to the projection of the cost of PLATO that Douglas (3) made five years ago. Figure 2 shows that his estimate of what the hourly cost of PLATO would be today is about \$1.85. The hourly cost of using mainframe PLATO at Delaware is higher than his projection. However, as will be shown in the next section of this article, the cost of using PLATO on an off-line microcomputer is considerably less.



The Continually Decreasing Cost of PLATO Hardware

It is indeed heartening to bear witness to the continually decreasing cost of PLATO hardware. When the Delaware PLATO Project started in 1974, the price of extended memory was one dollar for a sixty-bit word. Today, thanks to new memory technologies, it is only twenty cents a word. When the second memory upgrade was made to the Delaware PLATO system, it was actually cheaper to purchase twice as much of the new memory than it would have been to double the size of the old memory.

In addition to the decreasing cost of central site hardware, another index of the declining cost of educational computing equipment is the price of PLATO terminals. Table 5 shows how this price has steadily decreased from \$15,000 in 1974 to \$2,900 in 1981, and this during a time of rampant inflation.

Table 5

The Continually Decreasing Price of PLATO Terminals

Year	Price
1974	\$15,000
1975	10,500
1976	9,000
1977	6,500
1978	6,000
1979	5,300
1980	4,900
1981	2,900

The new micro PLATO station promises to reduce the operational costs of using PLATO at an even faster rate than projected by Douglas (c.f. above, figure 2). Virtually any PLATO lesson can be converted to run off-line on the micro PLATO station, as long as the lesson does not require mainframe features like communications among users or extensive data keeping, features that are not available on micro PLATO. The present capital cost for a micro PLATO station that can also run CPM (Control Program for Microcomputers) is \$7,950. Amortizing this over seven years and dividing by 2,000 hours of annual use yields an hourly cost of \$0.57. Adding in annual maintenance at \$1,008 and an estimated annual courseware usage charge of \$150 produces a total hourly cost of \$1.15, which is about half of the present hourly cost of running on the Delaware PLATO system. Advances in microelectronics promise to reduce the price of the micro PLATO station just as they have reduced the price of the on-line terminal (c.f. above, table 5).

With the proliferation of stand-alone microcomputers that are on the market today, the pros and cons of running on-line or off-line are being debated. The lower costs of running off-line are certainly attractive, but the need for mainframe services in the areas of communications, student records, data analysis, computer-managed instruction, and courseware development is widely recognized. It does not take long for a programmer working on a stand-alone microcomputer to appreciate the value of the PLATO mainframe in terms of authoring support and programming time.

Universities that use PLATO can have the best of both worlds. They can use the mainframe to develop and test courseware, using all of PLATO's on-line authoring aids, and then they can down-line load their courseware into the micro PLATO station for delivery in a low-cost format.

The Cost Effectiveness of the PLATO System

Avner (4) aptly stated that "cost effectiveness is situation-specific rather than product-specific." Whether or not a given application of PLATO is considered to be cost effective depends upon the price that is being paid for PLATO services, the manner in which this price compares with alternate methods for providing instruction, and the value that one places upon the unique benefits of CBI.

An experiment that was conducted by Johnson and Flake (5) at the University of Nebraska during the 1977-78 academic year serves as an example of how the manner in which PLATO services are obtained can influence cost effectiveness. This experiment sought to determine which of three methods was most effective in teaching new students about the main library. The three methods were computer-assisted instruction (PLATO), tutorials, and orientation tours. It was found that students learned significantly more from the PLATO program and from the tutorials than they did from the tours. PLATO and tutorial students performed equally well. However, it was decided to abandon both PLATO and tutorial methods because they were too expensive. The authors do not quote figures for how much the tutorial method would have cost, but they do state that with PLATO "...it would have cost the library over \$30,000 to present the one-hour program to 4,000 students." If the University of Nebraska at Lincoln had a PLATO system similar to the one at Delaware, it would cost only \$9,880 to deliver this program, and it might well have been decided to continue the PLATO program. At the University of Delaware, PLATO is being used extensively to orient new students to the library with a package of lessons developed by the University of Delaware Library.

Given the manner in which the costs of traditional instruction are escalating, if the hourly cost of CBI is not already less, and in many courses it already is, the decreasing cost of microelectronics will soon make the CBI contact hour cost less. However, not all courses can be taught through computer-based techniques. Molnar (6) has estimated that with today's technology 25% of all college courses can be computer-based, and that 25% of each remaining course could benefit in some way from instructional computing. It is important to realize this present-day limit of what computers can do in education.

Those courses that can be computer-based will realize benefits that are of much greater value than mere dollars. Studies by Arsenty and Kieffer (7), Culley (8), Hofstetter (9), Poore, Qualls, and Brown (10), Dugdale and Kibbey (11), and Siegel, DiBello, and Gilpin (12) have documented the significant improvements in student achievement that the use of PLATO has produced in biology, languages, music, basic skills, elementary mathematics, and general education degree (GED) preparation, respectively. Necco (13), Barlow (14), Nichols (15), and Bitzer, Boudreaux, and Avner (16) have shown that not only is student achievement increased, but the time needed for instruction has also been greatly reduced for projects in operations research, biomechanics, art, and nursing, respectively.

Faculty members and students often complain that the level of instruction is never right for all members in a class. Some are fast learners; others are slow learners. Some drop out because a course is too boring; others drop out because they can't keep up. The individualized, self-paced approach of PLATO has proven to be a remedy for this problem of individual differences. With PLATO, the anxieties associated with the traditional classroom are minimized. Students are free to respond as they wish without fear of ridicule from either peers or teachers. In such an environment learning is a lot of fun, and motivation is high. PLATO enables students to develop a richer intuitive grasp of complex phenomena through graphic visual representation. Especially applicable to PLATO is the saying that "A picture is worth a thousand words." The ability of PLATO to create interactively a display suited to the student's specific learning needs cannot be overestimated.

PLATO lessons can provide students with access to a wide range of data for checking out hypotheses. A good example of this benefit is the population dynamics program. Stored in the computer are up-to-date data on the populations of countries throughout the world. The student is able to set variables which affect the futures of those populations, such as time and extent of famines and can then see the effects of those variables upon future generations of the populations. Students can also learn more of the complexities of phenomena through modeling and simulation. In addition to giving students drill-and-practice and tutorials on various subjects, computers can also allow the student to create models and to simulate complex phenomena. For example, the student can make electronic circuits, design clothes, compose music, draw pictures, mix chemicals, breed fruit flies, and then study the results of the models and simulations.

PLATO also provides students with an anonymous way of asking questions about sensitive matters. The use of anonymous sign-ons whereby students can use PLATO without revealing their identities has encouraged students to ask questions and get responses on sensitive issues which they would normally be afraid to discuss. PLATO's group notesfile capabilities enable students not only to ask questions and to get responses on their own personal questions, but also to see the questions and responses anonymously written by other students. Especially in the area of sex education this has proven to be an excellent means of allowing students to explore sensitive personal issues.

All of these benefits add to the value of PLATO and help justify its cost. But perhaps the most telling justification comes in the form of testimonials from students who have benefited from the use of PLATO. On attitudinal surveys that have been administered over the years at Delaware and at other schools, students consistently report that they enjoy using PLATO, that they want to use PLATO in more courses, and that they really like PLATO's self-paced instruction with immediate feedback. Many students report that PLATO has helped them get past mental blocks that were holding them back in their coursework. The value-added benefits of the PLATO system are perhaps best summed up in a letter from a seven-year-old girl who had been using PLATO all afternoon, and whose parent was getting tired and was trying to entice her away from the PLATO classroom by offering to take her to the pizza parlor. She wrote:

"I like PLATO better than
Pizza. And if you knew how
much I like Pizza, that
would be quite a compliment!"

In closing, it should be pointed out that a contact hour on the Delaware PLATO system costs less than a pizza.

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COST AND BENEFIT: CAI AT UNIVERSITY LEVEL

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ABSTRACT

The aim of this presentation is to identify the costs and benefits of CAI at the University level. The results indicate that CAI can be subdivided into several modes, and each mode has a different benefit: cost ratio. For each mode of CAI, the costs are generally determined by the way in which the courseware library is obtained. If the courseware is developed "in situ" the cost of CAI is about ten times more than the cost of the hardware alone. However, if courseware or the greatest part thereof (90%) is obtained from commercial sources, the cost of CAI will be two times more than the cost of the hardware alone.

The benefits of each mode of CAI vary quite remarkably. The opinion of the author is that the cost-effectiveness of CAI at the University level is situation specific.

INTRODUCTION

The cost of any innovative technology must in the final analysis be motivated by the expected benefits. In real terms, at the University level, this would mean increasing the pass-rate of the students. To estimate the expected benefits, one normally consults reputable literature or unbiased experts.

This task is rather difficult, due to the lack of literature with sufficient detail and the scarcity of unbiased experts in South Africa. However, from the available sources of information, the salient features which affect the costs and benefits of CAI may be obtained.

A similar problem is encountered when trying to determine the cost and benefit of other educational aids. For example, little information is available which correlates the usage of overhead projectors to the pass-rate of students, yet few lecturers would deny the benefits of overhead projectors.

BENEFITS

Before we can discuss the benefits of computer-assisted instruction (CAI), this term must be defined. J R Allen (1) presented the following definition in 1972, "In the widest sense, 'Computer-Assisted Instruction' refers to any application of computers to teaching."

In 1979 D W McCulloch (2) defined instructional software as, "Any computer program which, by design:

- (a) causes learning to occur
- (b) provides students or staff with feedback, more or less detailed, on the learning process
- (c) provides an experience which is believed to encourage or cause learning."

Such computer programs can be used in one or several of the following modes, according to M Dence (3):

- (a) Tutorial (for first time presentation of material)
- (b) Drill and Practice (for drill on information obtained from other sources)
- (c) Problem solving
- (d) Gaming
- (e) Simulation
- (f) Inquiry and
- (g) Dialogue

I would like to expand this list with one more mode, namely,

(h) Tutorial Generation on Hardcopy.

In modes (a) - (g) individual students or small groups of students interact with some electronic device, eg. Teletype printer, keyboard and visual display unit, touch-sensitive screen, etc. In mode (h), however, the computer generates random numbers and puts these numbers in specific questions which constitute tutorials. These tutorials are then printed on hardcopy and each student gets one. Thus the students get sets of problems in which the questions are similar but the data values are different. The lecturer gets a copy of each student's tutorial with the correct answers typed in by the computer. After the tutorials from the students have been collected and marked, the copies with the correct answers are handed out so that the students can see where they went wrong.

The benefits of some of these modes of CAI have been evaluated at the tertiary education level quite thoroughly; however, the evaluation of others has been very vague, thus making conclusions concerning them very insignificant.

The mode of CAI which has the highest benefit : cost ratio is simulation, especially in the natural sciences where the computer can be used as an heuristic device as shown by B B Sandel and R W Solomon (4). They found computer usage beneficial even with as little as ten students. Other examples of simulations may be taken from F T Hofstetter (5) - for teaching art, music and sports. Or from R H Simonsen and K S Renshaw (6) - for teaching pilots by flight simulating programs.

The mode of CAI which comes a close second to simulations in terms of the benefit: cost ratio is the tutorial generation on hardcopy. The reason for this is the low cost. This mode can therefore be used beneficially with small groups of ten or twenty students, or large groups.

The drill and practice mode is suited for subjects that can be presented very systematically. W Koch (7) has reported statistically significant advantages over traditional instruction by using this mode in foreign languages and mathematics. However, P Suppes and M Morningstar (8) have reported that "an additional 30 minutes of ordinary classroom drill and practice can accomplish the same results as a fifteen minute CAI program."

Thus the benefit: cost ratio of the drill and practice mode of CAI is much lower than that of simulations. Thus this mode can probably be justified only with large groups, i.e. a minimum of one hundred students.

The tutorial mode of CAI is usually employed with the drill and practice mode. The impression obtained from the literature is that this mode has a benefit: cost ratio slightly lower than that of drill and practice. This mode can probably be justified only with rather larger groups of at least one hundred and fifty students.

It is worthy of note that E M Magidson (9) has found the following in studies which compared traditional instruction (TI) to CAI. In 55% of the groups studied, CAI was as effective as TI while in 45% of the groups, CAI was more effective than TI. In these studies the CAI involved only the modes of tutorial and drill and practice.

The above findings concerning the benefit:cost ratio and minimum group size which would be necessary to make the particular mode of CAI justifiable, are summarized in Table 1. Data concerning the benefit: cost ratio of the other modes of CAI have not been reported in the literature in sufficient detail.

TABLE 1: SUMMARY OF THE RELATIVE BENEFIT : COST RATIOS OF THE FOUR MOST COMMON MODES OF CAI, AND THE MINIMUM CLASS SIZE WHICH WOULD JUSTIFY THEIR USE AT UNIVERSITY LEVEL.

CAI MODE	ESTIMATED RELATIVE BENEFIT: COST RATIO	MINIMUM CLASS SIZE IN WHICH CAI MODE IS JUSTIFIED
TUTORIAL	1	150
DRILL AND PRACTICE	2	100
TUTORIAL GENERATION ON HARDCOPY	5	10
SIMULATION	8	10
SIMULATION WITH ONE OR MORE OF THE OTHERS	10	10

R H Simonsen and K S Renshaw (6) have attempted to define the effectiveness of CAI over traditional instruction by using an "effectiveness factor"(EF). Their study did not discriminate between the different modes of CAI. The EF was calculated as follows:

$$EF = \frac{\text{CAI group performance gain} \times \text{control group instruction time}}{\text{control group performance gain} \times \text{CAI group instruction time}}$$

and their results are presented graphically in Figure 1.

COST

The cost of CAI can be divided into two main categories. The first and most important is the cost of the courseware. The second is the cost of the hardware. It is usually necessary to appreciate that in both categories start-up costs are normally higher than steady-state costs.

The cost of hardware can be divided into three sections according to D R Torrence (10). The first and easiest to establish is the purchase cost which is self-explanatory. The second is depreciation. This is based on the assumption that hardware and courseware have a limited useful service lifespan, as determined by their mechanical and technological life. The hardware mechanical life is usually taken as five years, whereafter the machine becomes too expensive to maintain, or spare parts become non-available. The technological life-time can also be taken as five years because with new technologies as for example random-access discs or voice-boxes, it becomes easier/cheaper to present a lesson with the new technology, making the existing hardware and courseware obsolete. Thus the depreciation costs per year, corrected for inflation, must be added onto the purchase cost in order to be able to continue the service by replacing the hardware and courseware after the first five-year period.

Thirdly, maintenance costs are those costs which are necessary to keep the service going for five years and would include items like fuses, globes, magnetic tapes and floppy discs, or routine cleaning of air filters and keys of keyboards. The cost of a maintenance contract is usually 15% of the replacement value of the hardware per year.

Thus the total cost of providing the service is the sum of the purchase cost, the depreciation cost and the maintenance cost.

The cost of developing courseware is the greatest budget item in a CAI project. This important fact is not always appreciated by prospective users of CAI, who believe that the purchase price of the hardware is the greatest cost in a CAI

budget.

The consensus in the literature is that one hundred man-hours are used to produce a one hour long CAI lesson. At R10 per man-hour for lesson editors (programmers/lecturers) a cost of R1 000 is necessary to develop an hour long lesson, and these 100 hours may be spread over one whole month of real time. Developing lessons which use simulations is twice as time-consuming (200 man-hours/hour-long lesson) and requires more innovative thinking than drill and practice or tutorial type lessons. Programs for generating hardcopy tutorials, on the other hand, are only one tenth as time-consuming as drill and practice or tutorial type programs.

The cost of developing a library of courseware can be reduced in three ways:

Firstly, the cheapest way is to purchase equivalent programs to those desired from software distributors. Courseware can normally be purchased at 0,5% - 10% of the development cost, about R10 - R100 for an hour-long program. This brings the price of courseware in line with other educational aids such as text books. The problems associated with this approach is that the courseware must be compatible with the recipient's hardware. This means that the courseware should be written in FORTRAN or BASIC, which at the moment are the only suitable machine independent languages. The program does usually not present the material in exactly the way that the lecturer would have liked it presented. This problem is also encountered with textbooks, however, and is not insurmountable.

Secondly, the approach suggested by J E Emery (11) may be used. This involves encouraging faculty members to take some of the responsibility of designing and programming their own programs. The advantage of this approach is that the salaries of the lecturers are provided for under a different budget heading, and their contribution comes as a bonus to the CAI centre. This saving is, however, only illusory since the University also pays the salaries of the lecturers.

Thirdly, a coaching/prompting type of authoring language can be used for tutorial and drill and practice type programs, and another language for simulation type programs. R H Simonsen and K S Renshaw (6) have shown that with a coaching/prompting authoring language, lesson preparation time is reduced by a factor of between three to five.

It is realized that all three approaches have advantages and disadvantages and the particular approach used will depend on the circumstances and aims of the CAI project in question.

In summary then, the cost of CAI is hardware and courseware (or personnel) dependent.

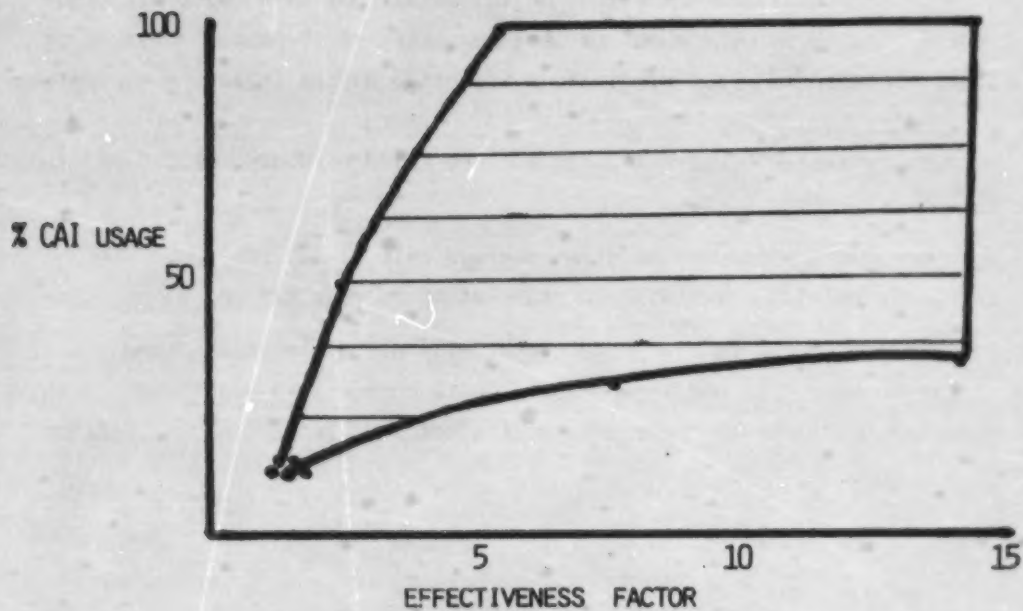


FIGURE 1: CAI EFFECTIVENESS FROM REFERENCE (9)

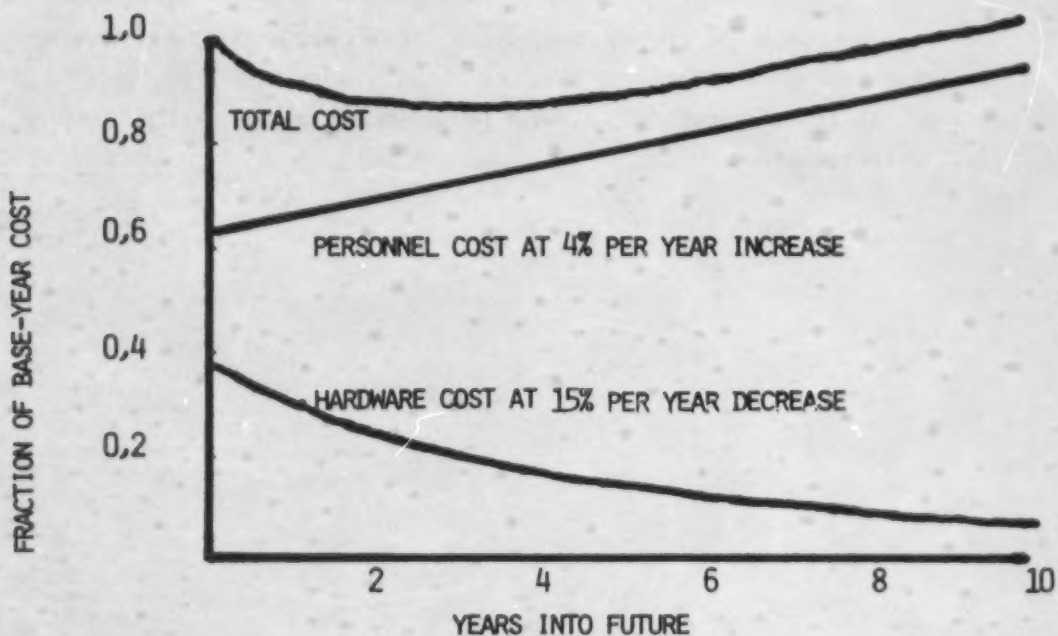


FIGURE 2: HARDWARE AND PERSONNEL COST TRENDS FROM REFERENCE (7)

J C Emery (11) has described the effect on the total cost of a University computing centre that is brought about by implementation of technical advances in the field of electronics. His predictions are based on the following assumptions:

1. A computer centre's current costs are one third hardware-related and two thirds personnel-related.
2. Hardware costs will decline at an average rate of 15% per year.
3. Personnel-related costs will increase at an average rate of 4% per year.

The above assumptions can be presented graphically as in Figure 2. From this figure it can be seen that hardware-related costs become less significant with time, declining to 15% of the base year cost after five years, and to 7% after ten years.

CONCLUSION

In conclusion it appears from the literature that computers can be employed in education in four main modes. These modes are simulations, tutorials, drill and practice and tutorial generation on hardcopy. These four modes have very significant differences in their benefit: cost ratios.

The costs involved in a CAI project vary quite significantly too, depending on whether courseware is developed "in situ" or obtained commercially. Indeed, it appears that the future growth of CAI will be dependent on the availability of high quality courseware.

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ABSTRACT

Two aspects of computer-aided education are potentially relevant in Engineering: the use of computers for repetition-lessons and as simulators of real-world situations. Due to the emphasis placed on synthesis in Engineering, the simulation usage of computers is by far dominant in this discipline. In Electrical and Electronic Engineering, simulation activities include both the usage of simulations to optimise a design by scanning a wide range of state variables as well as techniques to implement a realistic simulation. This department is very active especially in the latter field where a wide variety of methods are used, ranging from optimizing numerical methods for real time implementation of simulations to the design of special hardware and processors for man-machine interaction. The computer-aided education in this department thus quite often takes the form of the design of a computer facility, utilising computer-aided design, computer-aided development followed by computer-aided debugging and testing, all of which is done in a simulating environment. During such a sequence, the finite execution time of the digital computer has a very distinct effect on the dynamics of the simulated system.

In this paper a variety of methods to analyse and restrict the effect of this discretization are discussed as well as special computer systems of today and the future to implement realistic simulations.

COMPUTER-AIDED INSTRUCTION ON AN MBA PROGRAMME

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ABSTRACT

UCT's Graduate School of Business recently acquired a powerful mini-computer with interactive terminals and a range of educational and business software. The paper applies a particular model of the learning process in order to choose the most effective computer-based teaching methods for the MBA Programme. It is argued that this choice must take into account characteristics of the learner, the learning environment, the material being learned and the stage of the learning process. These elements and the current status of computer-aided instruction on the MBA Programme are described and basic policy guidelines are presented.

COMPUTER-AIDED INSTRUCTION ON AN MBA PROGRAMME*

1. INTRODUCTION

The degree of Master of Business Administration at the University of Cape Town is offered by its Graduate School of Business (GSB). For some time the GSB has had its own small in-house computer as well as remote access to the large university facility, but the nature of these facilities has not allowed extensive use of computers for teaching purposes. The recent acquisition of a powerful mini-computer with ease of use, interactive capabilities and compatible with a wide range of educational and business software has presented major opportunities to apply computer support on a broad front.

The objective of this paper is to describe the status of Computer-Aided Instruction (CAI) at the GSB and to present a particular model of the learning process which allows effective policy-decisions and the objective selection of computer-based teaching methods.

In the next section basic hardware and software issues are noted and six modes of computer usage for teaching purposes are described. Section 3 presents a particular model of the learning process and argues that the effective use of computers depends on characteristics of the learner, the learning environment, the material being learned and the stage of the learning process. Section 4 describes the structure and content of the MBA Programme at the GSB and presents the objectives and nature of current and planned computer-aided instruction on the programme. The final section contains broad policy guidelines for on-going management of CAI at the Business School.

2. BASIC ELEMENTS FOR IMPLEMENTING COMPUTER-AIDED INSTRUCTION

Hardware

The successful incorporation of computer-aided instruction on an educational programme clearly depends to a large extent on hardware facilities. The choice between micros, minis and mainframes is the first, difficult step. Chambers and Sprecher [1] state for instance:

"The advent of the microcomputer has resulted in heated debates concerning the relative merits of CAI systems supported by large-scale, powerful computer configurations as contrasted to the CAI capabilities of the micro-computers".

*Based on an unpublished paper submitted to the Department of Accounting, UCT, in part-fulfilment of the degree of M.Com. (BDP).

And in interpreting Hawkins' major international survey, Barker [2] notes

"respondents had equally mixed feelings about whether the source of computational and instructional power should be derived from a large machine, micro/mini, or a computer network".

Microcomputers offer a very inexpensive entry point, are portable, frequently have facilities such as colour graphics and eliminate wasteful usage of central storage facilities. Large main-frames have the advantage of economies of scale, central control, capacity for large scale packages and programming effort, and central data-base development and management.

The modern mini-computer however offers a possible compromise between these two extremes. Much software originally designed for main-frames is now available for mini-computers. Minis approach micros in terms of ease of use, and yet compare with main-frames in terms of storage capacity and processing power. Mini-computers generally cost substantially less than main-frames.

This is the route taken by UCT's Graduate School of Business which recently acquired a PRIME mini-computer together with 12 student terminals, an 80 mb discdrive, an 800 bpi tapedrive and a 300 lpm printer. The GSB also has an RJE link to the main university UNIVAC.

Important considerations in making this decision were

- cost of the facility
- operating system in terms of student use
- interactive terminal capability
- availability of business and educational software
- ability to emulate large business computer environments.

Software

The development and sharing of quality CAI materials has been termed "the single most critical issue in CAI today" [1]. There has also been criticism of "the massive accumulation of instructional software produced by relatively inexperienced programmers which is then marketed as a ready made source of solutions to educational problems" [3].

Fortunately, at least at the university level there are now organizations that review and disseminate proven courseware, CONDUIT being a prominent example [4]. Authors are assisted in programming educational material, which is subsequently reviewed, documented and adapted for ease of transfer. GSB has acquired several packages in this way.

Business schools are also in a fortunate position since much basic business software is directly useful for business education. For instance the use of financial modelling packages, data base management systems and statistical systems is described ahead. Business schools may also find it useful to access public sources such as the Johannesburg Stock Exchange.

Modes of Computer Usage

CAI facilities such as those described above can be used in several different ways on a teaching programme. Six broad modes of CAI are considered in this paper: tutorial, drill and practice, problem solving, simulation, inquiry and gaming.

In tutorial mode material is presented for the first time. A fact may be stated, elaborated in a few sentences and then the student given a problem to work out or blanks to fill in before being allowed to move to the next item.

In drill and practice mode, the student is led through a series of examples of increasing complexity or differing nature, in linear or branching fashion depending on the result of student responses.

Problem solving mode on the computer implies the provision of a computer and a programming language via which students are encouraged to tackle and solve problems. BASIC is the most well known language in this context.

In simulation mode a pre-programmed model is provided. The student is able to access the model and manipulate it by varying input data, selecting different equations, carrying out sensitivity analysis and in general exploring the simulated reality that the model represents.

Inquiry mode makes use of a database and a database management system such that students have rapid and generalised access to the available data.

Finally, in this context gaming may be regarded as an extension of simulation where the simulation model has the added element of competition. Typically student teams might represent companies in a competitive market place and make a series of decisions over simulated time. Effectiveness of the decisions might be measured by market share or profitability as well as verbal or written presentations.

In subsequent sections the use of these different modes of CAI will be discussed within the context of the chosen learning model and its application at the Graduate School of Business.

3. A LEARNING MODEL AND THE SELECTION OF INSTRUCTIONAL TECHNIQUES AT THE GRADUATE SCHOOL

Introduction

Given today's multiplicity of instructional techniques and facilities, institutions need to choose carefully or risk submerging students in a haphazard smorgasbord of conventional lectures, programmed texts, study modules, films, videotapes, written assignments, computer simulations etc.

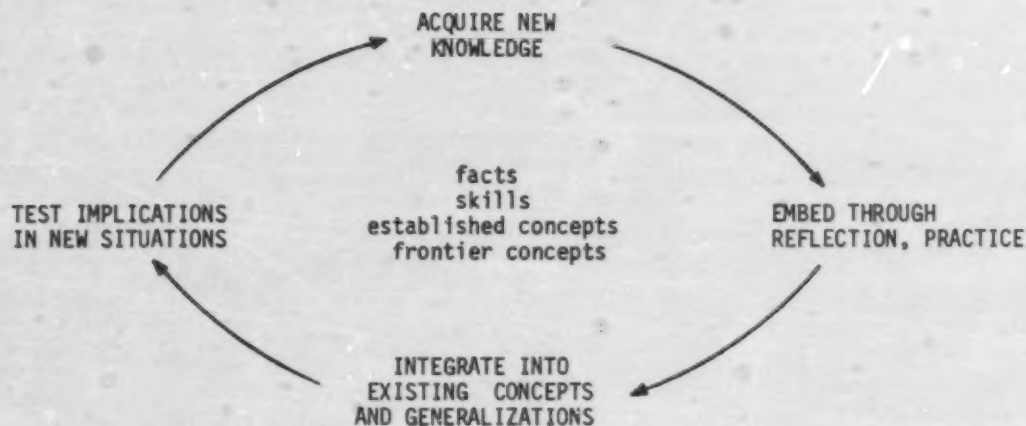
Rockart and Scott Morton [5] have proposed an operational model of the learning process that allows the instructor to choose rationally and effectively between different instructional techniques. Based on the so-called "experiential learning model" [6], this model will be briefly described and then applied to the selection of computer-based techniques in general and in the GSB situation in particular.

The Learning Model

In Figure 1, knowledge is categorized as facts (definitions, specific items and ideas), skills (procedures and their application), established concepts (theories, hypotheses and assertions that are well enough accepted to warrant minimal learned debates), and frontier concepts (recent developments and long standing unresolved issues open to debate). It is postulated that learning proceeds through four stages: new knowledge must be acquired, embedded, integrated and then tested.*

FIGURE 1

THE LEARNING MODEL



The model can also be represented as a 4x4 matrix in which each of the 16 cells is the stage in the learning of a particular category of knowledge. Reporting on extensive research, Rockart and Scott Morton conclude that, for most effective learning, different cells in the matrix have different requirements - e.g. rapid feedback, rich learning environment, accessibility to past data etc. A wide range of audio, visual, written and computer techniques are then classified in terms of their "learning attributes" and correlated with the cells in the matrix.

CAI techniques have particular and sometimes unique attributes. Figure 2 focusses on some of these and shows the connection between learning requirement and learning technique.

*cf. Stimulus-Response models [6] and Gestalt models of learning [7]. The Gestalt concepts of insightful learning and transfer of knowledge relate closely to the above stages of embedding, integrating and testing.

FIGURE 2

LINK BETWEEN LEARNING REQUIREMENTS AND CAI TECHNIQUES

Stage of learning/ type of knowledge	Learning requirement/ important attribute	Prominent CAI technique
embed facts, skills, established concepts	rapid, objective feedback	drill and practice
embed, integrate and test facts, skills, established concepts	individualized learning, learner control, assist structured clerical tasks	problem solving
	present structure clearly, allow data manipulation, provide rich environment	simulation and gaming
embed and integrate frontier concepts	fast access to relevant data and existing models	inquiry systems

Non-computer-based techniques are more closely associated with the acquisition of new knowledge. Because of the large percentage of all students' time devoted to acquiring facts and skills, attributes such as ease of use, low cost and decentralized availability are desirable. At least at the time of the study (1971-73), conventional textbooks, programmed texts and study modules possessed these attributes in far greater measure than, for instance, computer-based tutorial techniques. Acquisition of established and frontier concepts calls for the presentation of complex new information, dealing with unstructured material, rapid inclusion of new items and individualized attention. The lecture and guided class discussion are prominent in terms of these attributes.*

The GSB Environment

The selection of learning techniques depends as much on the learning environment and the learner as it does on the material being taught.

* The reader is referred to the cited work for a much greater appreciation of the depth and breadth of the original study.

MBA students at UCT's GSB go through a rigorous selection procedure. They are chosen on the basis of their response to a detailed application questionnaire, referees' reports, a lengthy interview and performance on the General Management Admissions Test (GMAT). While the successful applicants come from a variety of educational and working backgrounds, they almost all have prior university degrees and all have some working experience (the average is five years). The selection process ensures that the student body is intelligent, mature and strongly self-motivated.

The MBA Programme itself is very intense. Whether it is the one-year full-time, or the two-year part-time programme, 18 individual courses must be completed and a lengthy dissertation submitted. It is expected that each of the 280 two-hour class lectures/discussions will be preceded by at least the same amount of private study of prescribed readings and cases as well as small group discussions of pre-specified issues and problems.

Because of the pace at which the MBA programme runs and the amount of material to be covered, a rigorous structure has to be imposed and each student must keep to it. There are only limited opportunities for individual coaching, and there is no time for leisurely practice of skills learned. As in business itself students have to manage their time continuously and choose between the various demands upon them.

Within this context the judicious use of computer technology holds great promise. While the learning model and practical observation indicate that the traditional learning process - readings, case analysis, group and classroom debate - will continue to be most effective for acquisition of knowledge on the MBA Programme, it is at the stages of embedding, integrating and testing the new knowledge that the special attributes of CAI come to the fore.

Given appropriate hardware and courseware, all the techniques shown in Figure 2 can be employed at various stages of learning on individual courses. Where there is no time for more than a few manual or hand calculator exercises in finance or statistics, computer-based drill and practice and problem solving enable more, and more realistic examples to be tackled to embed and integrate new skills and concepts. Where complex time-dependent business relationships need understanding, the opportunity to experiment with computerised simulation models, exploring the events of several months or years in a matter of minutes, underlines the unique benefits of computer modelling. Where the implications of alternative economic theories can be tested by analysing banks of economic data using a variety of econometric formulae, the special advantages of inquiry systems are clear.

Perhaps because of the business orientation, maturity and determination of the typical MBA student, the challenge of tackling the computer and at the same time enhancing the learning process has led to considerable enthusiasm at GSB. The problem is not to promote CAI within the student body, but to control it. In the next section, the academic courses on the MBA Programme are sketched and present and planned computer support is described.

4. APPLICATION OF COMPUTER-AIDED INSTRUCTION

Academic Structure of the MBA Programme

Figure 3 shows twenty or so courses that are offered on the MBA Programme at UCT. With the exception of the Technical Report course which requires

FIGURE 3: MBA PROGRAMME - COURSE STRUCTURE



students to write a dissertation, all the courses employ the traditional lecture format and range in length from ten to twenty two-hour lectures.

The figure shows certain important features of the overall structure of the Programme. At the centre of the diagram are four of the so-called "core" courses. These courses are offered in the first term and provide a compulsory grounding on which subsequent courses will build. At the next level are further core courses offered in the second and third terms, in general building on those courses shown closest to them in the figure. The third level consists of "elective" or "special field" courses from which students can choose. Since these electives build on and deepen the knowledge already gained, the choice will depend on past performance and interest in the associated core courses, as well as future career objectives.

Finally on the perimeter of the diagram are a series of core and elective courses taken towards the end of the year. These are broadly based "integrative" courses intended to pull together the knowledge and concepts covered in previous courses.

As the MBA progresses, the general emphasis shifts from instructors' input, theoretical issues and "acquisition of facts and skills", to student output (projects, assignments, presentations), practical business applications and "testing of frontier concepts". The Programme ends with the Technical Report which is a major individual exercise in applied research.

Incorporation of CAI

Elements of CAI have already been incorporated on several courses at GSB and a number of new packages are currently being loaded and tested. The source for much of this material has been CONDUIT [5].

In the financial area, hands-on training in the basic skill of Financial Modelling is offered early in the year. The basic teaching is via the Interactive Financial Planning System (IFPS), although SIMPLAN and EPS are also available. Acquisition of this skill provides the basis for subsequent use of computer models in Management Accounting, Corporate Finance and Advanced Finance. The objective is to improve the integration of accounting and financial concepts by allowing instructors to set problems of realistic size and complexity. Initially students might use the computer to manipulate pre-written financial models. Subsequently they might build their own models to assist in the solution of financial cases.

The sequence of courses including Statistical Method, Operations Management and Advanced Management Science is supported by software such as the Statistical Package for the Social Sciences (SPSS), Quantitative Experimental Analysis, Computer Models in Operations Management and Linear Programming. The problems and cases that are set start with simple interactive exercises in basic statistics and progress through the year via more complex cases in Operations Management to the fully fledged formulation and solution of optimisation models using Linear Programming. The objective is to embed the basic procedures by providing meaningful problems and quick feedback and ultimately to improve the integration of quantitative concepts by providing a richer environment for exploration.

Economics and Marketing concepts are supported by a series of Policy Games in Macroeconomics, a Diffusion Game and a Marketing Game incorporating advanced techniques such as perceptual mapping and conjoint analysis. These facilities assist in the initial acquisition of new skills and concepts and eventually provide a sophisticated environment in which students can test their insight into advanced management techniques.

The course in Decision-Support Systems is a new one and by its very nature will require a computer-based environment. Use will be made of the supplier's data base management and inquiry facilities supplemented by other modelling and analytical software to simulate real world requirements for computerized decision-support.

An important opportunity for MBA students to test their knowledge of various business skills and concepts is afforded by the computerized Business Simulation run late in the year. During a few days management teams compete with each other for profits and market share over two years of simulated time - an exercise in quantitative business analysis as well as in group decision-making under stress.

Finally the GSB computing facilities are of course available for students to use on their Technical Reports. Programming can be undertaken in BASIC and FORTRAN for those problems not amenable to the use of the higher level packages.

In the next section the role of CAI at UCT's Business School is summarised and some of the important policy guidelines pertinent to this activity are noted.

5. POLICY GUIDELINES AND CONCLUSIONS

The policy guidelines for computer-aided instruction discussed here are aimed at ensuring the most effective use of the special features of CAI and avoiding the risk of submerging MBA students in a welter of new-fangled techniques. By their nature these guidelines are specific to the GSB environment and each other institution will find it has its unique set of requirements too.

- CAI should be an adjunct to the existing teaching process

In terms of the overall GSB environment, and the nature of the individual - group - class structure, CAI should be used selectively in support of the traditional teaching process, rather than supplementing whole courses or eliminating instructors.

- CAI should progress in step with the overall MBA process and technological barriers should be minimised.

The MBA Programme comprises a progressive broadening and deepening of business knowledge. The use of computer techniques should reflect this process starting with straightforward interactive tasks and progressing to more complex problem-solving and open-ended activities such as simulation studies and modelling. MBA students should not be forced to program or learn complicated computer procedures.

- CAI elements should be selected primarily on the basis of their unique benefits.

The special attributes of CAI such as the ability to telescope time, ability to present structure, provision of a rich environment, support for structured, clerical tasks and for unstructured data manipulation, and opportunities for rapid feedback and learner control, should be exploited selectively - particularly at the stages of integration and testing of business knowledge.

- CAI investment should be based on enhancing rather than replacing traditional learning mechanisms.

The unique features of CAI in a business school environment relate to enrichment of the learning process rather than replacement of existing mechanisms. Investment decisions should take this view rather than that of a cost reduction exercise.

- CAI activity should mirror the computer-based business environment.

The use of computers on an MBA Programme offers a unique opportunity for managers and potential managers to experience the new world of computerized business in a risk-free environment. Learning techniques and activities should build on this in the knowledge that long term perceptions of the value of computers are being formed.

CONCLUSION

With the recent acquisition of new computing facilities the Graduate School of Business now faces an ongoing series of decisions regarding their optimal use on the MBA Programme. The wisdom of these decisions will have great impact not only on the effectiveness of MBA instruction, but on the perceptions of graduating students regarding computers and their application in business. With this in mind it has been essential to formulate and apply a cohesive policy that takes into account the unique attributes of computer-aided instruction and its selective application to the learning process in higher education.

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THE POCKET CALCULATOR AS AN EDUCATIONAL AID

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ABSTRACT

A short perspective is given on the development of the scientific pocket calculator. This is followed by a discussion of the educational considerations and problems encountered with the use of pocket calculators by Engineering students. The policy followed by the Faculty of Engineering of the University of Stellenbosch for the introduction of pocket calculators into the educational program is discussed. Finally, the characteristics of the new generation of pocket calculators are discussed, with some speculation of possible future developments in this field and the associated field of micro computer systems.

THE POCKET CALCULATOR AS AN EDUCATIONAL AID

1. INTRODUCTION

Two new consumer products, resulting from technological developments in Micro Electronics, appeared on the world market at the beginning of the previous decade: the electronic wrist watch with digital display, and the pocket calculator. Both products quickly became popular and within two years turnovers grew to millions of units per annum.

The scientific pocket calculator differs from the more commonplace four-function calculator in that special function keys are provided for the calculation of mathematical functions, such as logarithmic, exponential and trigonometric functions, to name but a few.

The era of the scientific pocket calculator started with the introduction of the revolutionary HP-35 by Hewlett-Packard in the USA. This calculator was advertised as a "fast, extremely accurate electronic slide rule with a solid state memory similar to those in computers"

The HP-35 was a primitive machine, measured by today's standards. Apart from the standard functions add, subtract, multiply and divide, special keys were provided for the functions x^y , $\log$, $\ln$, e^x , $\sqrt{x}$, $\sin$, $\cos$, $\tan$, $\arcsin$, $\arccos$, $\arctan$ and $1/x$, as well as one memory register. All this for approximately R400-00. A unique characteristic of this machine was the Reverse Polish Notation that was used. This compact mathematical notation is still used by this company in all its calculators.

Other firms were quick to enter the market for scientific pocket calculators, notably Texas Instruments in the USA and Sharp, National and Casio in Japan. Initially, the Japanese calculators were not too successful. This was because they did not use a strict mathematical notation,

where priority is given to multiplication over addition.

The competition in the market for pocket calculators was severe. Prices dropped (the price of the HP-35 halved within two years), and new models made their appearance almost monthly.

Scientific pocket calculators developed rapidly. The first programmable pocket calculator, the HP-65 was introduced by Hewlett-Packard in 1974 at a price of approximately R800-00, quickly followed by the SR-52 from Texas Instruments at about R450-00.

The further development of pocket calculators followed two trends: the Reverse Polish calculators, typified by the Hewlett-Packard models, and calculators using standard mathematical notation, including brackets, as typified by the models from Texas Instruments and most Japanese manufacturers.

Both kinds of calculators have adherents and critics. The main arguments are [1] that machines which use standard mathematical notation are easier to use, as most people are well-versed with this notation. Adherents of the Reverse Polish Notation point out the compactness of this notation (which is especially important in calculators with a limited program memory), and point out that the mental discipline imposed by this notation leads to better accuracy in problem solving.

The development of the scientific pocket calculator, as outlined above, has culminated in modern machines like the HP-41 from Hewlett-Packard and the TI-59 from Texas Instruments. Both machines are programmable, and can be coupled to peripherals such as printers. The TI-59 can accept up to 940 steps of program or provide up to 100 data storage registers. The HP-41 can be expanded (at extra cost) to over 2000 program steps or 319 data storage

registers. Both machines handle subroutines and logic decisions under program control.

Peripherals which are becoming available for the HP-41 even make it possible to control electronic measuring instruments such as volt meters, and to transfer data directly from the instrument to the calculator where it can be used in calculations.

The above discussion has been limited to pocket calculators as they developed during the past decade. Pocket calculators based on a totally new concept were introduced recently. More will be said about these at the end of this paper.

II. EDUCATIONAL CONSIDERATIONS

The introduction of pocket calculators generated a lively debate between scientific and engineering educators.

Very few people had any doubts about the desirability of pocket calculators, and welcomed these machines for their own use. But whether this was a good development for students, was another matter.

The main concerns were:

Will students who use pocket calculators at university still be able to do mental arithmetic?

Will students tend to have complete trust in their calculators, and lose the all-important (especially for engineers) "feeling" that an answer is correct or incorrect? Won't the discipline enforced by the slide rule be missed?

Will students try to replace reasoning by calculating, since the "cost" of calculations will be reduced?

Will students still master important arithmetic techniques, like the use of tables of logarithms?

The answers to all these questions were in part affirmative. However, the advantages of pocket calculators overshadow the disadvantages completely.

It is a fact that the arithmetic ability of the modern "calculator-scientists" compares poorly with that of their pre-calculator counterparts. The often-quoted example of the engineer who uses his calculator to find out what $2+2$ is, is not so far-fetched. The author is of the opinion that this loss of ability is not important. One can, after all, always have a pocket calculator handy. If you doubt your arithmetic abilities. On the other hand, complex calculations, which would have forced one to use a log book, or even a computer, can be effortlessly handled on a calculator in any place, at any time.

The educational possibilities that were made available by pocket calculators, especially in the engineering disciplines, compensates fully for any diminished arithmetic ability. Countless examples of engineering techniques which could literally not be taught in the pre-calculator era of slide rules, are now commonplace in the modern classroom. Modern filter theory and the associated design techniques which require accurate arithmetic, iterative calculation of the roots of non-linear functions and simple optimisation routines, to name a few, cannot be taught effectively without the aid of the pocket calculator. It must be kept in mind that a technique is mastered by practice, without which it remains just a concept.

The second concern is inherently more important than the first. The answer to the question is affirmative. A person tends to accept results obtained on a pocket calculator as correct, and tends to lose his feeling for magnitudes. The lecturer must emphasise the use of additional calculations to test the correctness of answers. Emphasis must also be placed on the evaluation of results by students to develop their feeling for different orders of magnitude, and to learn to recognise results that are obviously incorrect.

The replacement of reasoning by calculating is an important disadvantage of the pocket calculator. To give an example: a number of mathematical techniques exist by which it is possible to sketch graphs of functions with a minimum number of calculations. These sketches are not accurate, but show tendencies of functions and are an important aid in engineering synthesis (i.e. creative design). It is always a temptation to a student not to learn these techniques, and to rely on his pocket calculator to calculate functions point-by-point. This time-consuming process is a definite drawback, as students tend to remain unfamiliar with the properties of the functions that describe systems. This temptation cannot be wished away. A lecturer has to take pains to motivate the need for these techniques thoroughly. He must also use evaluation techniques to consciously apply pressure on his students to master these techniques.

On the other hand, replacement of reasoning by calculating is often a vehicle to convey new concepts to students. The concept of a mathematical function, which maps the values taken on by an independent variable onto a function plane, becomes clear to a student when he sees how this mapping works on his own calculator. The calculation of important visualising aids, such as graphs, also becomes a painless process with a programmable pocket calculator.

The concern that students will not master arithmetic techniques, such as the use of logarithms, has also been confirmed. However, this not important. The pocket calculator has made these techniques obsolete, and they are no longer required.

The pocket calculator brought about an important educational change. Arithmetic and arithmetical techniques have become less important. It is no longer important to examine the arithmetic capabilities of a student in detail, as these capabilities are supplied by the pocket calculator.

There has been a marked shift towards the examining of techniques and methods. From an educational viewpoint, this shift is extremely desirable, as it enhances the efficiency of the educational process by cutting down on the time spent on arithmetic techniques, allowing more time to be spent on mathematical and other conceptually more difficult techniques.

This shift in emphasis has, specifically in the case of Electronic Engineering, made it possible to include more advanced material in the undergraduate course. This material, which covers discrete-time and sampled-data systems theory, has become much more important in recent years, due to the rapid drop in the prices of computers. Without the humble pocket calculator, it would not have been possible to equip students fully for their careers.

III. THE POLICY OF THE ENGINEERING FACULTY REGARDING POCKET CALCULATORS

When students started to buy electronic pocket calculators, the Faculty of Engineering at the University of Stellenbosch appointed a committee to investigate the use of pocket calculators by students in depth, and to make recommendations on the orderly use of pocket calculators.

After consideration of the educational aspects allied to the use of pocket calculators, the committee came to the conclusion that students should be encouraged to use pocket calculators. The committee therefore recommended that no upper limit be placed on the capabilities of pocket calculators used by students. For the protection of students, a lower limit was specified, ensuring that all calculators would be suitable for examination purposes.

Mindful of the resistance to change that would be encountered with the introduction of pocket calculators, it was also recommended that pocket calculators be prescribed from the second year of study. This would enable

first year students to become acquainted with the more traditional calculating aids.

The Faculty accepted these recommendations, and prescribed that all Engineering students, with the exception of first year students, must equip themselves with pocket calculators which meet the (minimum) specification of the Faculty from June 1975. Calculators could be used in examinations if the lecturer concerned approved.

The introduction of pocket calculators Faculty proceeded smoothly. The use of pocket calculators by first year students was reconsidered, and it was decided to prescribe pocket calculators to first year students w.e.f. June 1977.

As pointed out above, no upper limit was placed on the calculators which students could use. Programmable calculators were allowed, provided that previously developed programs would not be allowed in examinations.

Soon, calculators with continuous memory, which retain programs or data even when switched off, became available. It would have been impractical to enforce the regulation on programs in examinations. The Faculty therefore decided to allow students to bring programs to examinations.

With decision the Faculty deviated from accepted educational practice, because it allowed students to take electronically stored notes to examinations. At that time examinations in a number of subjects were already declared "open", in which students were allowed to bring handbooks and other previously prepared material to examinations. In effect, the decision of the Faculty partially "opened" all exams in the Faculty.

The educational justification for this decision was that the emphasis of examination had shifted from the execution of sample calculations, and the echoing of facts, to the examining of techniques, specifically how well students understood these techniques.

Lecturers were forced to have second thoughts on precisely what they wanted to examine. It was concluded generally that electronically stored notes could be eliminated as a significant factor by placing the emphasis of evaluation on the insight of a student, on his ability to see results in perspective. It should not so much be a question of "how", but "why".

The Faculty's policy, not to place an upper limit on the calculators that students were allowed to use in examinations, begs the question whether a student who buys a very powerful calculator has an advantage over his colleagues. The answer to this question can once more be found in what is evaluated in an examination. The student's arithmetic capabilities have become less important, and emphasis is placed on his insight. Where numerical calculations are required in an examination they must necessarily be limited to those that can be performed effectively on a machine that meets the Faculty's specification. With this limitation on allowable calculations, a powerful machine holds no advantage.

The Faculty reconsidered the calculator specification, and changed it to make programmable calculators mandatory in 1979. This was done with homework assignments in mind especially, and made it possible to include iterative problems in tasks.

With the introduction of a new generation of pocket calculators that are programmed in the BASIC high-level language, the Faculty maintained its stand and did not introduce an upper limit in the specification for pocket calculators.

The Faculty's enlightened stand on pocket calculators helped students to accept and use pocket calculators with enthusiasm. This is reflected by the fact that the students started an Electronic Calculator/Computer Club under the auspices of the Association of Stellenbosch Engineering Students. This club strives [2], among others, to encourage better use of programmable pocket calculators by Engineering students, and to encourage the development of new programming techniques.

IV. THE NEW GENERATION OF POCKET CALCULATORS

A new concept in pocket calculator design emerged at the beginning of 1980 with the introduction of the first pocket calculator that is programmed in the BASIC high level language.

Where the older generation of pocket calculators were programmed in a low level language, more or less on the level of an assembler language, the new pocket calculator represented an upward step by bringing the programming of a pocket calculator closer to a conceptual level. Even though this calculator has its faults (some of which have already been improved upon in later models), it marks the start of a new phase in the development of the pocket calculator.

The previous generation of pocket calculators, as represented by the HP-41, has been developed fully. The new generation opens new doors for the further development of pocket calculators.

The modern pocket calculator must not be seen as an isolated piece of equipment, but rather as the front end of a more complex computer system.

The new concept will eventually make it possible to develop complex programs on a pocket calculator, from where they can be loaded into a larger computer for fast execution.

The pocket calculator will also be complimented by micro computers (i.e. microprocessor based systems that are no longer portable and are more powerful than pocket calculators by orders of magnitude). Just as the pocket calculator became a consumer item in the previous decade, it must be foreseen that micro computers will become consumer items in this decade. They will be found in homes where there are no scientifically-oriented persons. (At present the tendency already is that more micro computers are bought for games and recreation than for calculating purposes).

The new generation ensures that the pocket calculator will not become obsolete in the near future. It will become integrated into ever more complex computer systems.

These developments will change an old saying: In the future, children at school will have to learn about the *four R's*: reading, 'riting, 'rithmetic and 'rogramming!

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COMPUTER-MANAGED INSTRUCTION WITH SPECIAL REFERENCE TO SECOND LANGUAGE

TEACHING

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ABSTRACT

In this paper I will discuss the concept of computer-managed instruction as a subdivision of CBE (Computer-based Education).

With regard to CMI I will refer to the concepts included under CMI as well as the functions of such concepts. This will be followed by an in-depth discussion of a specific version of CMI, viz. PLATO Learning Management (PLM).

I will explain how PLM will be used in a language course called English for Science*. Examples of screen copies will be presented.

Finally a conclusion is drawn to the effect that for CMI to succeed in any educational environment, it will need commitments in the areas of manpower, course material, and money.

*The official title for the course is *English for Science Students in South Africa*. In this paper the abbreviation *English for Science* will be used.

1. OVERVIEW OF CBE

The concept of computer-based education or CBE has become almost a household word over the last two decades. More and more schools and other educational institutions are looking towards computers as possible teaching aids. Almost overnight everybody has to some degree become aware of the possibilities presented by computers in the field of teaching.

In "An Introduction to Educational Technology" (1) Rushby identifies a number of problems facing educators today. These are: the particular needs of individual students; modular courses with more sophisticated assessment methods pose student management problems; student centred courses pose problems of resource management. The above-mentioned problems almost force educators to look for solutions in the field of educational technology. Educators like to believe that educational technology, and specifically computers, can solve some of these problems. At this stage I grant them that computers can indeed offer some possible solutions, but on the otherhand there are at present some limitations.

Before we proceed, it is perhaps best to give an overview of what is understood by CBE or computer-based education. The term CBE is used as an umbrella term that includes the following: CAI or computer-assisted instruction, CSLA or computer-supported learning aids, and CMI or computer-managed instruction. (figure 1).*

CAI usually refers to a situation where the computer plays an interactive role in the instructional process. It means that the computer assumes the role of an instructor and therefore handles the instruction in certain areas (e.g. drill and practice) on behalf of the teacher. Let me assure you that I do not refer here to the computer as a replacement for the teacher. On the other hand I must admit that a computer can handle certain instructional procedures far better than the teacher and with infinite patience as well.

A second term that I want to explain very briefly is computer-supported learning aids or CSLA. In this case the computer is used exclusively as an aid in research. It could be used for data processing, retrieval of information, *et cetera*.

The area that I want to explore in depth is indicated by the term CMI: computer-managed instruction. Sometimes this area of computer activity is also called CML or computer-managed learning. CMI is the process where the computer manages the instructional opportunities. As Rushby puts it: the computer is "cast in a background, supportive role in which it helps to manage, rather than to provide, learning opportunities." (2).

By using the computer in a supportive or managing role, it relieves the teacher of tedious and time-consuming management tasks. He is thus left with more time to devote to the essence of teaching. If the computer is used as the manager of the instructional process, it can fulfil the majority of the following tasks: construct, mark, and analyse tests for diagnostic or assessment purposes; keep records of student performance and progress through their courses; provide individual guidance for each student, directing and advising him on the basis of his performance in a particular course; and report on the performance and progress of students to various governing bodies (tutors, committees, *et cetera*). Now I want to turn my attention to a specific manifestation of CMI, viz. the Control Data PLM system: PLATO Learning Management. My reasons for focussing on this system specifically are two-fold. I have gained first-hand experience of PLM over the past 18 months and I believe it is comprehensive and powerful enough to handle almost any instructional management task necessary at school, college and even at university level.

*See Addendum 1 for graphics.

2. INTRODUCING PLATO LEARNING MANAGEMENT (PLM)*

As stated earlier, OMI can solve many of the management problems of assessment, documentation, and decision-making found in individualized programs. A OMI system, such as PLM, comprises three components, viz. testing

record-keeping
prescription generation.

Each of these components will solve specific management problems found in individualized instruction.

Before we take a closer look at the different components of PLM, let us take note of the fact that PLM was developed by Control Data Corporation in 1976. Since that date there has been an updating and improvement every year. Many of these improvements involved requests made by users of PLM. We may now take a closer look at the three components of PLM.

2.1 Testing

One of the problems facing teachers today is how to assess students on a regular and reliable basis. If one thinks of big classes, limited time and overloaded syllabi, then the problem becomes even more acute. This is one problem that PLM can solve. The system allows learners to take tests whenever they are ready and not only when the teacher has time to set a formal test. Tests appropriate to the student's progress are given throughout the curriculum. These are criterion-referenced and not norm-referenced tests. There are several issues that effect the use of the PLM system for testing:

2.1.1 Modes of testing

It should always be kept in mind that testing should not exceed more than 15% of the time spent in a course by the average student.

2.1.2 Test items

There are four different types of test items that could be used in PLM. These are: multiple choice (world famous in computer testing), true-false, matching (a specialized version of multiple choice), and numerical questions. The latter type is not used for language testing. Other types of test items that require monitoring, e.g. performance testing and essays, are regarded as inappropriate for most individualized courses.

2.1.3 Test item bank

All the items for a given objective constitute the test item bank. It is suggested that the test item bank should contain at least twice the number of items specified for each objective. Creating enough test items is usually a major task for one coursewriter. It is therefore suggested that a team of writers should contribute to such a test item bank.

The system allows the teacher to monitor a student's progress. Students also get immediate feedback on their test scores. Testing in PLM involves five different steps, viz. storing of questions, generation of test items, printing of test items as well as answers, on-line presentation and scoring, and the generation, storing and reporting of data in connection with item analysis.

*In my discussion of PLM extensive use was made of Control Data documents and on-line material.

The PLM system has two different modes of testing, viz. on-line testing, where a terminal is needed for every student, and off-line testing where printed copies of the tests are used. The latter may be scored by the teacher or by the computer.

There are certain distinct advantages in each of these two modes of testing. With reference to on-line testing the following advantages can be mentioned: continuous tailored testing, immediate student feedback, greater test security, easy and less expensive test modification, and individual tests generated to match each student's level of progress. On the other hand, we may distinguish the following advantages in connection with off-line testing: low cost operation, minimum concern about computer reliability, testing in any location and not necessarily only where terminals are available, and testing of large groups at the same time.

2.2 Record keeping

The documentation problems, associated with individualized courses, can be solved through the record-keeping component of PLM. In individualized courses a large quantity of data is generated. In this regard I refer to storing, assessing, and generating student curriculum records.

An analysis of student's records will reveal his strengths, weaknesses difficulties, and progress. Such an analysis will also help the teacher to validate his test items - a factor which is gaining recognition in modern education.

We can thus say that the record-keeping facility of PLM facilitates the information needed to keep the learner's records by

- allowing frequent reference to current information so that learners are given appropriate tests as well as learning materials;
- producing frequent and accurate reports and summaries on the curriculum, the learner, and the instructional resources;
- maintaining the privacy of records for each learner.

2.3 Prescription generation

The above-mentioned two components of PLM are prerequisites for the third component, viz. prescription generation or prescription of study materials. Once testing and record-keeping have been completed, the third component will come into operation. It will select appropriate learning resources (CAI lessons or textbooks). These learning resources will be well-timed (at a point when the student knows that he needs study materials), challenging (teaching him what he needs to master an objective, nothing less, nothing more), and motivating (material designed for a very specific purpose).

The PLM system will prescribe one or more learning resources for every individual student - based on his test performance.

3. STRUCTURE OF PLM

The PLATO Learning Management structure includes instructional units, modules, courses and a curriculum. In terms of the project that I am working on at the moment, two courses are part of the curriculum; each course comprises a number of modules and every module a number of instructional units.

The IU is the basic building block in a PLM curriculum. (fig. 2). Each IU contains one educational objective, e.g. the student will identify three actions taken by government to curb inflation. This means that a module which comprises ten objectives will have an equal number of instructional units.

An IU is used to test whether a student has mastered an objective. The author will compile a bank of test items that can be used to generate a test. (fig.3). This will be done by the computer on a random basis. If a student does not demonstrate mastery, additional tests can be generated without using identical questions.

It is the author's task to specify a testing strategy for each IU. (fig. 4). Such a strategy will determine how many questions should be included, how the questions will be presented (sequentially or randomly), and the conditions under which a test should be terminated before its completion. The latter could also be called test termination conditions.

PLM makes it possible for two feedback messages to be stored: one for mastery and the other for non-mastery. (fig. 5).

The next part of the PLM structure is the MODULE. It can be regarded as a major part of the PLM curriculum. It contains the information necessary to generate a student test. It is possible for the author to supply a module introduction that will inform the student about the content of each module. (fig. 6). This will be shown to the student when he starts working in a module. Apart from the content specification the message will also identify the number of questions as well as the standards for module mastery.

On the module level the author has to specify the order in which the IU's will be presented, test termination conditions and whether previous mastered objectives will be presented again. These conditions are part of the testing strategy. (fig. 7).

For every module there is a learning resource library. This library will specify the learning resources and their descriptions as well as the objectives taught by each LR. (fig. 8).

All the modules are contained in a library. A number of these modules will form a course. In other words: a course will consist of modules. The author must specify the modules to be included in a course. Up to 28 modules may be included in one course. (fig. 9).

On the course level the author has the option to specify Variable Management Strategies (VMS's). This option allows the author to specify which course modules are to be used in a VMS as well as those that are required and those that are optional. (fig. 10). A course may have a maximum of 7 VMS's. This means that an author may have several student groups, each working under the control of a specific VMS. An author may decide, for example, that 10 students in a first-year class will need to work through modules A through D; other students may need to do modules A, B, E and F (in that sequence); a third group may be required to complete modules A, B, G and H (in that sequence). Seven different combinations of the types mentioned above are possible on the grounds of VMS's. This is a good example of how the computer can be used to accommodate students with different needs in one course - something which is extremely difficult in conventional teaching.

From a different point of view one can say that each VMS specifies which modules are to be used in a course; it has its own module hierarchy, modules specifications (testing strategy and scoring procedure), course scoring (mastery criteria, grading scales), and course rules (feedback, et cetera). (fig. 11).

The final part of the PLM structure is the CURRICULUM. A curriculum consists of a number of related courses (a maximum of 15). The VMS's also play a role

on the curriculum level. Here they function on a basis similar to that on the course level, viz. to specify course hierarchy, control messages to be displayed to every student (e.g. objective, testing strategy, scoring procedure), control feedback (display question score, present feedback for a specific IU), and test interaction (no-risk testing, option to skip test and study assignment). The Variable Management Strategies on the curriculum level control the so-called curriculum rules. (fig. 12).

To summarize one could say that

- * each PLM curriculum can have from 1 to 15 courses;
- * each course in a curriculum may contain from 1 to 28 modules;
- * each module can contain from 1 to 30 objectives and from 1 to 1 800 test items;
- * each curriculum may have from 1 to 7 VMS's. (fig. 13).

With reference to figure 13 we can say VMS 1 gives a student access to course 1, modules A through C and in that order. VMS 2 uses courses 2 and 3 - the modules in course 2 are to be taken in the order A-B; in course 3 the modules are to be taken in the order B-A-C. VMS 3 and 4 use only some of the modules in each course.

4. IMPLEMENTING PLM IN A LANGUAGE COURSE

In this part of the paper I would like to explain how PLM will be implemented in the English for Science curriculum which is being developed at present. I would also like to present an explanation of a student's progress through the curriculum.

4.1 English for Science curriculum

This curriculum forms part of a CBE project which is at present being developed by the Institute for Language Teaching. The curriculum contains two courses, viz. Reading comprehension and Academic writing. Every course will consist of a number of modules. Every module in turn will include a number of objectives and for that matter, IU's.

On the PLATO system there are two system routers which could be used to route students through their learning materials. PLM is one of these routers. The routing capabilities of PLM will be used in the English for Science curriculum.

4.2 Student progress through English for Science

When a student signs-on to the PLATO system he will do so as part of a PLM group that was specially created for the English for Science curriculum. The first time he enters PLM it will be at the curriculum level. (fig. 15). Subsequent entries will also be at this level, but then the router will take him to the point in the course where he had previously been working. A "Welcome back!" message, which is displayed to him, is part of the built-in system messages.

Now back to the student who signs-on to the PLATO system. At the curriculum level the curriculum rules will determine which course he has to take. (fig. 15.1). When he chooses Reading comprehension as prescribed, he will be sent to the module level of the Reading comprehension course. (fig. 15.2). At this level he will be shown that there are six modules of which he may choose module 1. (fig. 15.3). In Module 1 he will be faced with a number of choices. He may decide to take a test, see his study assignments or see the objectives. The PLATO system will, however, advise him to take a test. In that way he will discover which study assignments are necessary.

If the student decides to take the module test, he will be branched to objective 1 in IU 1. (fig. 15.4). Before he starts the test, the objective is stated. He is told how many questions are available and what the criteria are for mastery. Once he has started the test, he will continue through all the IU's. After a test has been completed, he will be informed whether he has mastered an objective or not. When the last IU has been completed he will see a summary of his test performance.

The next step for the student is to see a list of Learning Resources. (fig. 15.5) from which he has to select those prescribed for the unmastered objectives.

It should be pointed out at this stage that there should be a LR assigned to every objective. If a student has mastered one or more objectives he will be allowed to skip specific lessons. This is possible because the tests in PLM are criterion-referenced and not norm-referenced. This in turn is one characteristic of tests designed for individualized learning.

When the student has completed his study assignment (which is a PLATO lesson in the Reading comprehension course) he may return to PLM to take the test again. If the study assignment is not a PLATO lesson but printed material, the student may be prohibited from taking the test. This is done by a lock-out mechanism which could be set to prohibit the student for a couple of hours from taking the test. He could also be locked out until the instructor decides that he may take the test again.

It is also possible in PLM to correlate test performance to the use of LR's. In this way the LR effectiveness could be determined. If the LR is a PLATO lesson then PLM will also compile statistics of lesson uses. This may be of interest to instructors.

4.3 Examples of Reading module 2 (readm2)

When inserting data into PLM the instructor has the options in fig. 16 available to him (on the module level).

According to option 3 a different PLATO lesson may be used as a test. This is very useful if there are aspects in a test which cannot be handled by PLM, e.g. a timing device used in testing reading speed and comprehension. In such a case a PLATO lesson could be used and the information (test results, etc.) could be transferred to PLM for processing. This means that, although PLM may lack one or more facilities, the PLATO system will have those facilities. The testing strategy (option 5) may be set for sequential or random testing. The choice will be determined by the content of the tests.

Options 6 specifies how mastery of the module is determined. In this case the student has to master all six IU's before mastery is assigned.

Let us now choose option 2 and then IU 1. (fig. 17). We now see the objective as well as other information that relates to this specific IU. The student will have to answer five questions and he will be awarded mastery of the objective if he correctly answers 80% of the questions.

We will now go back one display (fig. 16) and then select option 4. This option takes us to the Learning Resources. (fig. 18). This is a typical LR display where the instructor has to specify all the information needed. Note that that no. 4 links this LR to specific objectives. In this case one LR teaches two objectives. In no. 5 the author specifies the information that will inform the student about the content of the lesson.

If we go back from the LR display (fig. 18) to the previous display (fig. 16) we can select option 7. It will display the messages that the student will see at specific stages in his progress through the module. (fig. 19).

By way of a summary I would like to highlight the student's progress as controlled by PLM.(fig. 20). PLM is a very powerful router. In my opinion it truly manages the learning process. The standard set and the facilities included by PLM are to be regarded as the minimum. This statement is not to be seen as a challenge to other CMI systems. It is meant to alert educators who are contemplating acquiring a CMI system (micro or main frame) to take note of this fact; to do a thorough needs analysis before they jump onto the bandwagon of computer-based education!

Computer-managed instruction requires a substantial educational commitment if is to be effective. Despite this hurdle, it can be introduced gradually. At first it can be used to support existing courses. The development of new courses can follow in due course (3).

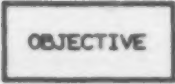
The use of CMI will also affect the training of teachers and administrators. To develop material for CMI is by no means a one man's task. A team effort will produce much better results but such teams must be trained preferably by the different institutions for tertiary education. Computer-managed instruction, then, is a challenge, a delightful experience for teachers as well as students, but it does not come all by itself. In its final analysis it requires three m's: manpower, material, and money!

REFERENCES

1. Nicholas John Rushby, *An Introduction to Educational Computing*, Croom Helm, London, 1979, p. 9.
2. *idem.*, p. 52.
3. *idem.*, p. 105.

Figure 1

THE IU



OBJECTIVE

Figure 2

THE IU

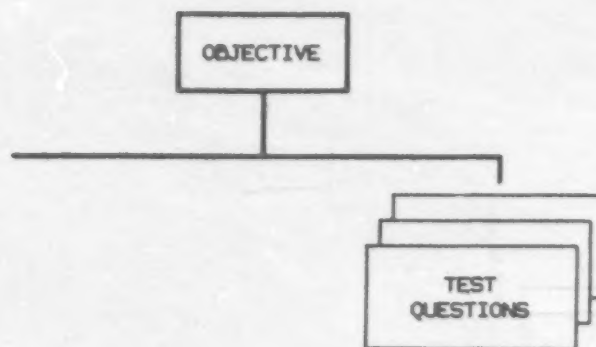


Figure 3

THE IU

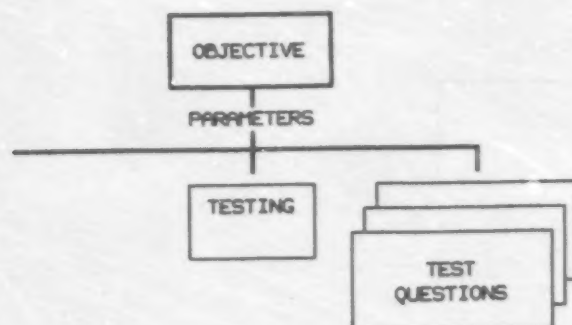


Figure 4

THE IU

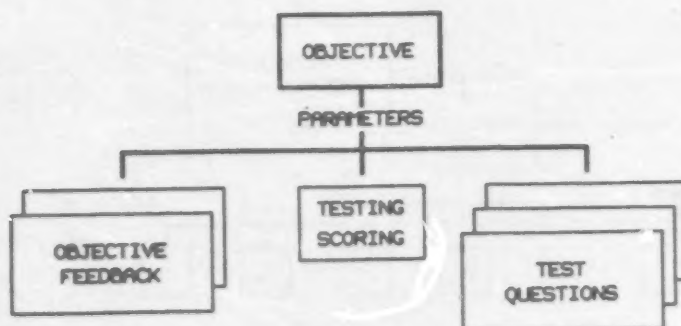
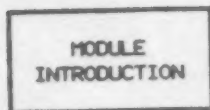
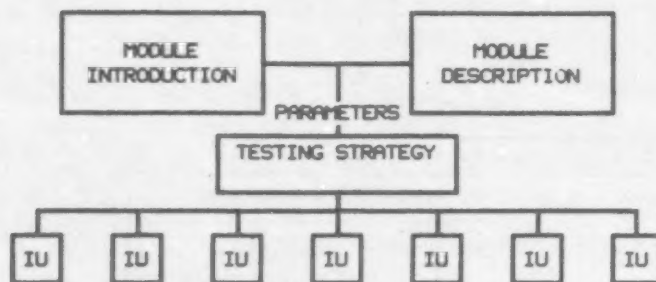


Figure 5

THE PLM MODULE

Figure 6

THE PLM MODULE

Figure 7 373

THE PLM MODULE

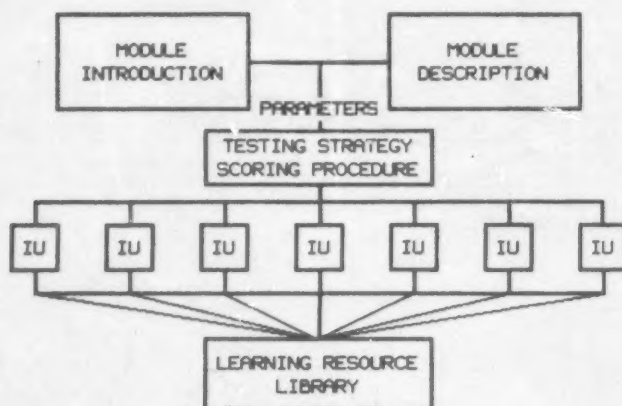


Figure 8

THE PLM COURSE

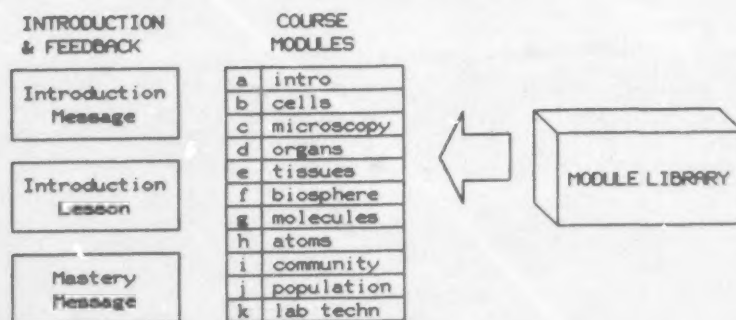


Figure 9

THE PLM COURSE

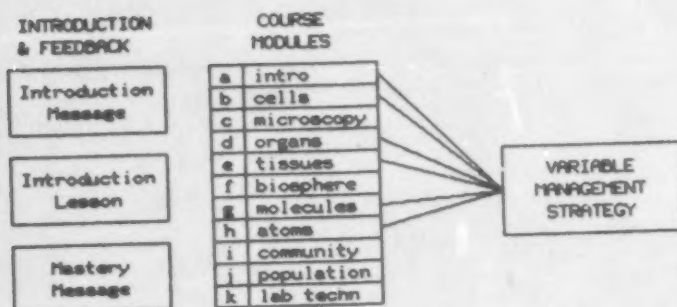


Figure 10

THE PLM COURSE

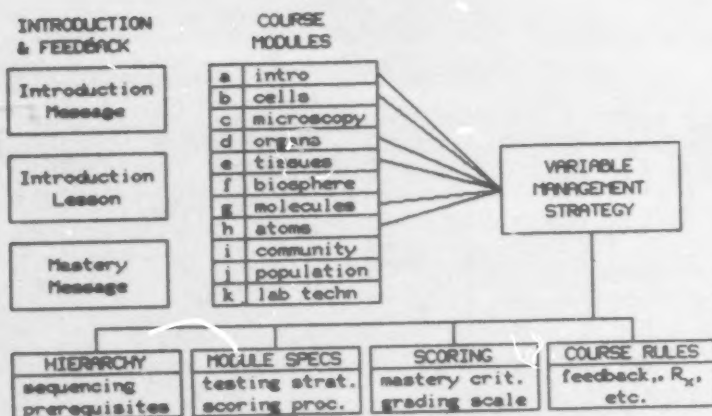


Figure 11

THE PLM CURRICULUM

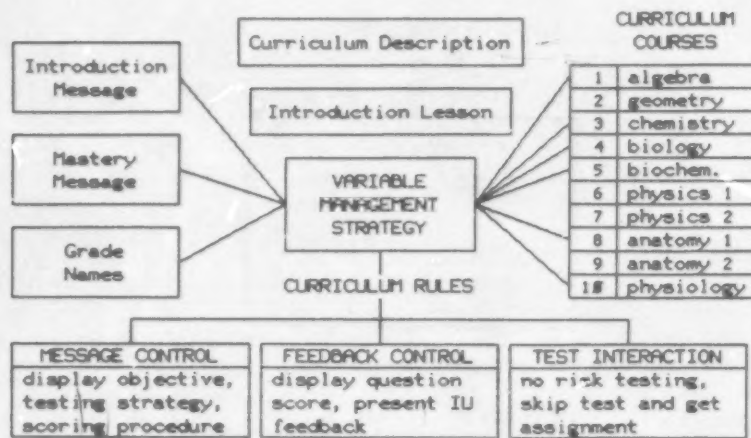
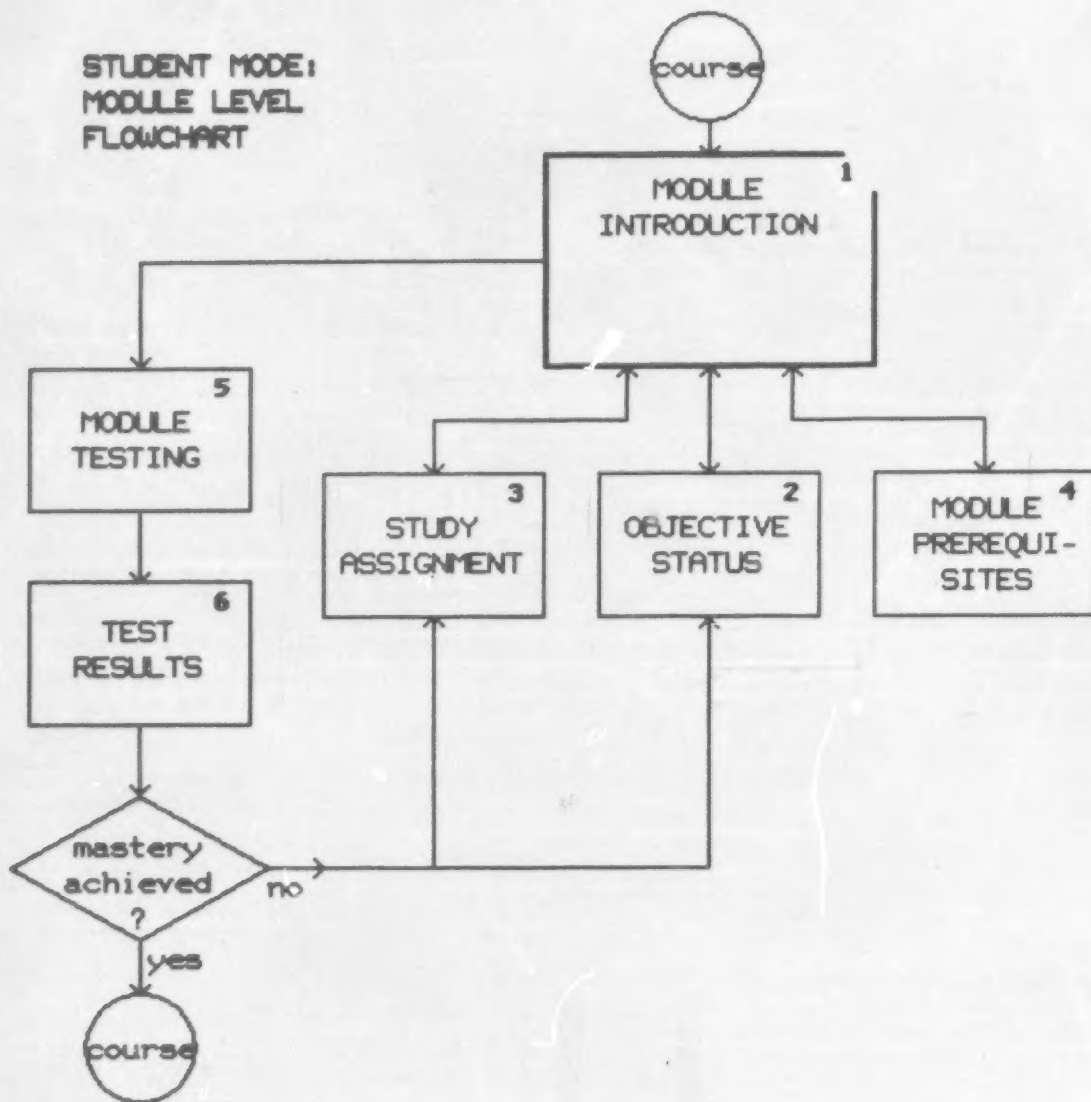
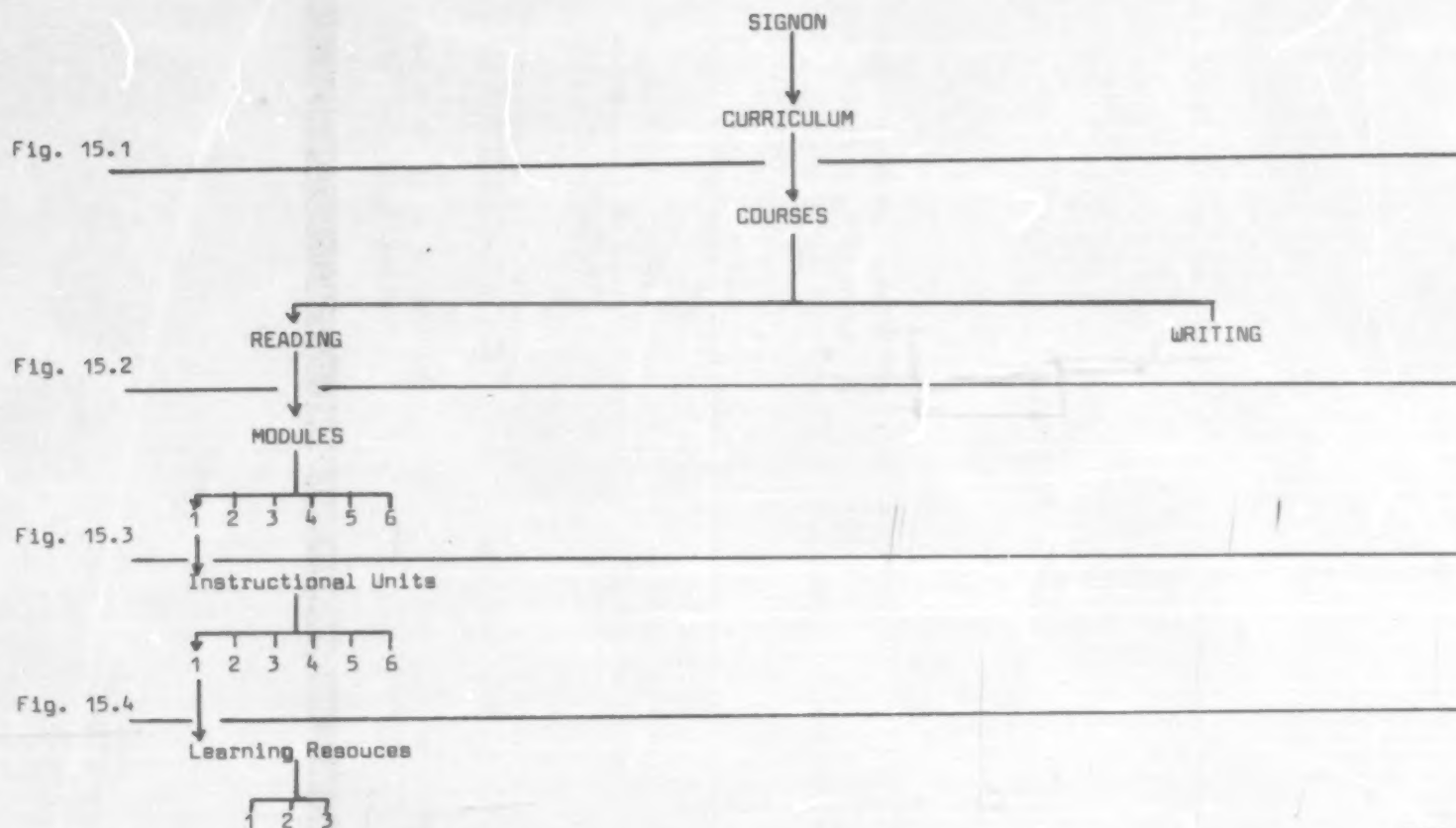


Figure 12

PLM CURRICULUM		VMS1	VMS2	VMS3	VMS4
<u>COURSE 1</u>		1		1	
Module A		1		2	
Module B		2		1	
Module C		3			
<u>COURSE 2</u>			1	3	
Module A			1	1	
Module B			2		
<u>COURSE 3</u>			2	2	1
Module A			2	1	
Module B			1		1
Module C			3		2

Figure 13

Figure 14



E-ATC Lesson Item Management	
1. <u>Title: Sequencing</u> (module file = readm2)	2. <u>IUs/Questions</u> (6 IUs entered)
3. <u>Lesson used as a test</u> (option not in use)	4. <u>Learning Resources</u> (3 LRs entered)
5. <u>Testing Strategy</u> Sequentially measure only unmastered objectives.	6. <u>Scoring Procedure</u> Module Mastery is assigned when student masters 6 IUs.
7. Messages	
◆ Student Introduction:	entered
◆ Mastery Feedback:	entered
◆ Non-Mastery Feedback:	entered
Module Space Used = 78%	

ENTER ITEM NUMBER.

Figure 16

1. IU ♦ 1 of 6: intro

MODULE: readm2

2. OBJECTIVE

Identify the introduction in the description of a process.

3. CLASSIFICATION: Unclassified

4. QUESTIONS (5 entered)

5. QUESTION GROUPS (none)

6. TESTING STRATEGY:

♦ Sequentially present all questions

7. SCORING PROCEDURE:

♦ Mastery is awarded when student:
correctly answers 88% of possible questions.

8. FEEDBACK:

♦ Mastery and non-mastery feedback entered.

ENTER ITEM NUMBER.

LAB to add an IU after this one
SHIFT-NEXT to display IU 2

Figure 17

Learning Resource * 1 of Module: readm2

1. Title: Description of a Process
2. Classification: Knowledge
3. Mode: PLATO Lesson a. Lesson Name - read21
 b. Unit Name - proses1
4. Learning resource teaches objectives:
 1-2
5. Instructions & description for students:

This lesson teaches you the sequencing
of different steps in processes.

Enter a number or letter to change an option.

SHIFT-NEXT for resource *2

BACK to select a different LR.
SHIFT-HELP to delete this LR.

Figure 18

INTRODUCTION AND FEEDBACK

MODULE: Sequencing

1. STUDENT INTRODUCTION

In this module you will learn about sequencing and enumeration in scientific texts.

2. MASTERY FEEDBACK

You mastered this module.

CONGRATULATIONS!!!!

3. NON-MASTERY FEEDBACK

You did not master this module. You should complete your Study Assignment before you attempt the test again.

Figure 19

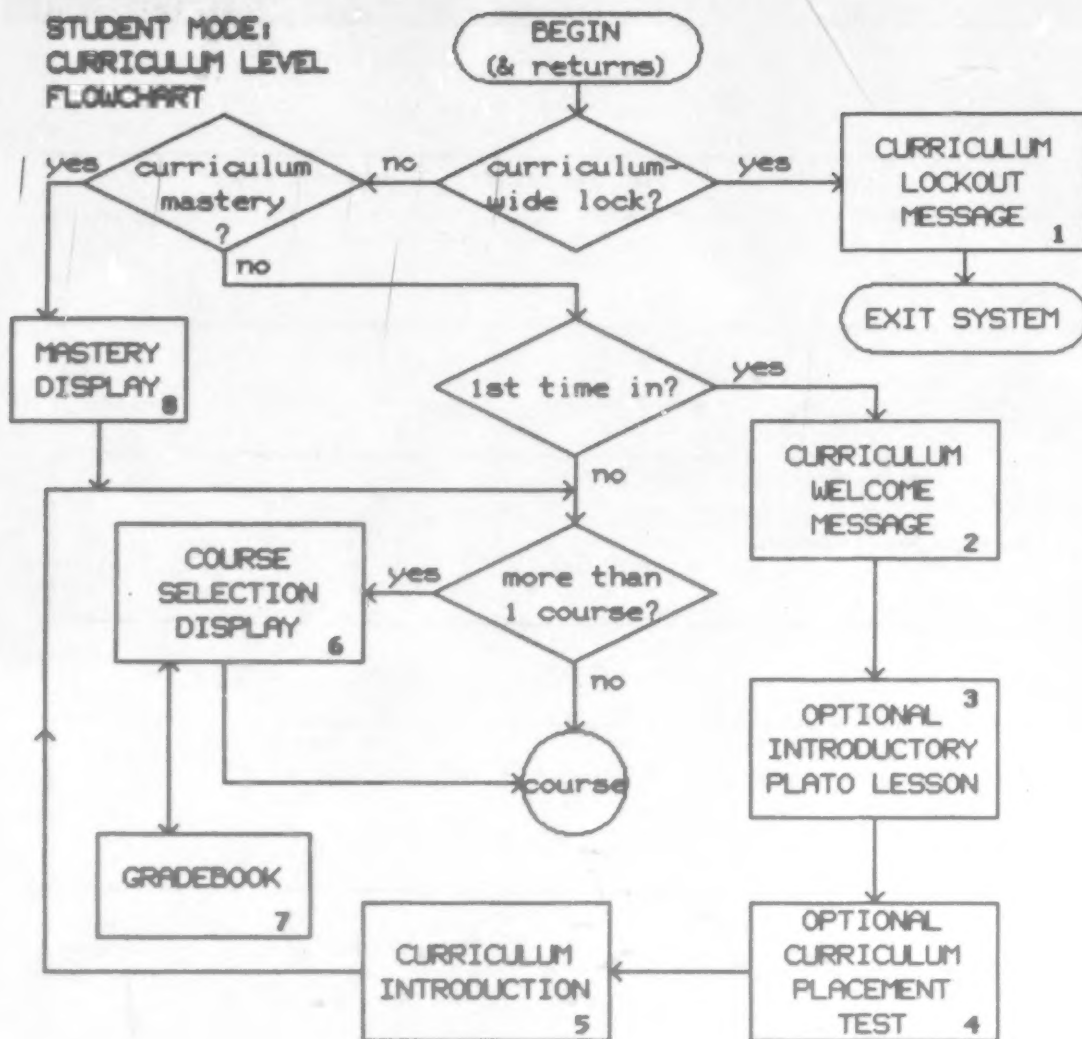


Figure 20a

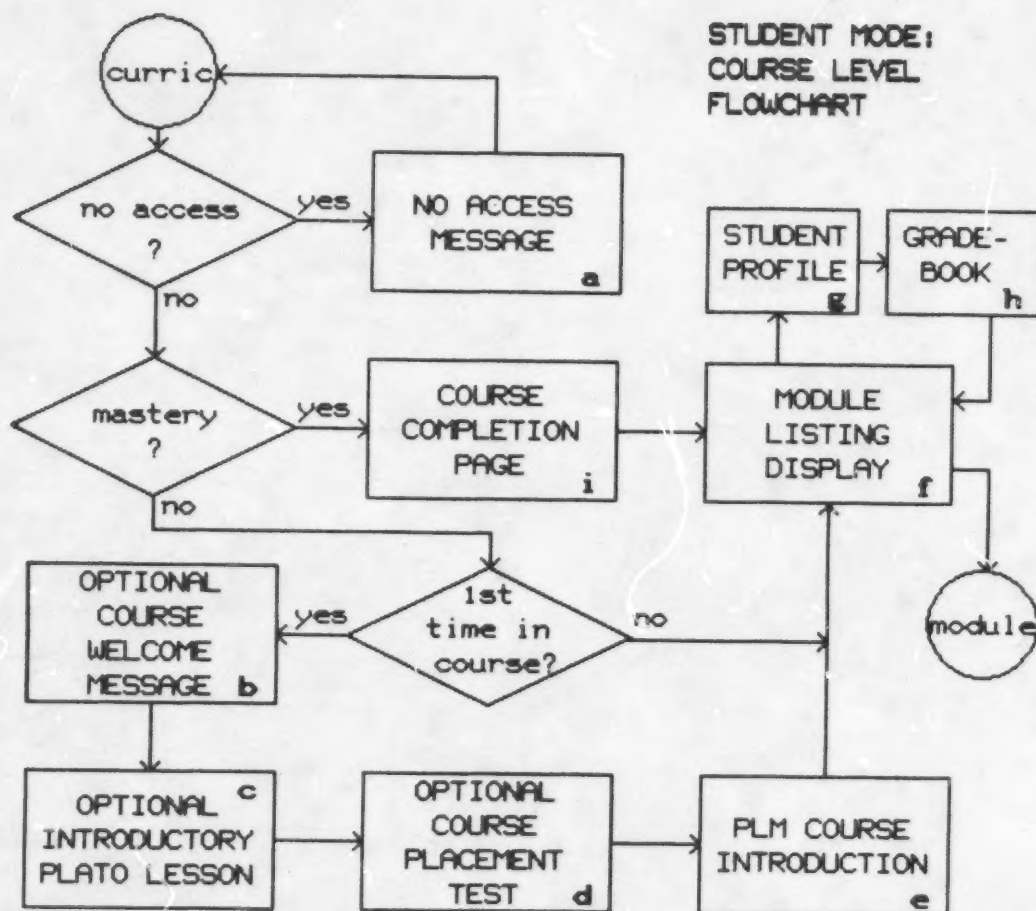


Figure 20b

SECOND LANGUAGE LEARNING AND COMPUTER-ASSISTED LANGUAGE INSTRUCTION

(CALI)

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ABSTRACT

In view of the contradictory judgements of CALI and in order to assess the merit of these judgements, second language teaching principles which accumulated through varying second language methodologies will be isolated and CALI evaluated within this framework.

Direct Method

- 1 Second language teaching should teach language, not about it;
- 2 it should give precedence to primary language skills i.e. hearing and speaking;

Audio-Lingual Approach

- 3 it should present language items in structures;
- 4 it should provide a large amount of language drill;

Transformational-Generative Linguistics

- 5 some deductive teaching of grammar rules is necessary;
- 6 language is generative, free expression should be allowed;

Communicative Approach

- 7 drills should be meaningful;
- 8 instructional material should be adapted to learner's needs;
- 9 content should be presented in context;
- 10 communicative use of language should be taught;
- 11 discourse should form the instructional material;
- 12 the culture of the target population should be part of the content;

Individualized Instruction

- 13 second language should be individualized;
- 14 all technological aids should be implemented.

CALI can meet the majority of the requirements of current second language viz. no's 1, 3, 4, 5, 7, 8, 9, 11, 12, 13, 14. This is not reflected in existing CALI programs. Many are still written largely in the grammar-translation method.

CALI can not teach the generative use of language or communicative competence. These could be viewed, however, as an advanced stage of second language learning.

ONCE MORE INTO THE BREACH
THE CASE FOR COMPUTERS IN LANGUAGE TEACHING

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ABSTRACT

The role which educational technology has been able to play in language teaching remains disappointingly small.

Based on a recent South African survey of the acquisition and usage patterns of the major innovation in language teaching, language laboratories, some probable causes for the resistance to their introduction and the high level of disengagement at school level, are put forward under four categories: economic, technological, methodological and socio-psychological.

The possibility of these trends recurring in the case of computers in language teaching is considered, and proposals are made to create a climate conducive to the broad acceptance of computer assisted and managed learning by language teachers.

ONCE MORE INTO THE BREACH
THE CASE FOR COMPUTERS IN LANGUAGE TEACHING

Arie Blacquiere
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The recurring theme

When you have been involved with language teaching for more than thirty years you are surely permitted to raise a sceptical eyebrow when some unbridled enthusiast predicts that computers are about to revolutionise language teaching. After all, you have heard it before, not just once, but several times. It's a little bit like a substitution drill where the word "computer" is deleted and the blank filled with the names of various technological aids. They said it about the gramophone, and 16 mm sound film, the tape-recorder and more recently about video. But the actual effect of all these innovations in the area that counts - the language classroom - has been rather like the ripples on a pond when a pebble has been plopped into the water.

It can be argued, of course, that the problem with all these other aids was that they were simply tacked on to the currently popular method. Being essentially teacher-dominated, it was the man (or woman) up front who introduced the aid at the time when he deemed it appropriate or convenient. The learner's role remained largely passive. If there was any interaction at all, it was with the teacher because he alone could evaluate and provide feedback.

Programmed learning

The protagonists of programmed learning will want to point out that immediate feedback is the main feature of their approach, and to that extent it is true that there is interaction between the learner and the programme, whether this is being presented to him by a machine or in print. We shall need to return to this point a little later on, but first I would like us to look at what has happened to one of programmed learning's more successful offsprings - the language laboratory[1]. I consider that it offers the best available basis for a prognosis about the role which computers could play in language teaching. What is more, I venture to prophesy that it is within the framework of existing or similarly motivated installations that the computer is likely to make its most frequent appearance in language teaching.

Types of language laboratories

Language laboratories, as we know them today, can be divided into two main types: audio-active (AA) and audio-active-comparative (AAC).*

While it frequently happens that learners in an audio-active laboratory are physically separated from each other (by partitions and/or isolating headsets) the teaching strategy is still group instruction. The lesson material is played from the teacher's console and all must proceed in lock-step at the pace dictated by the programme (or the teacher, if he chooses to override it). It is possible for the teacher to listen in to individual learners, but to interrupt for correction means that the learner misses a portion of the lesson because the tape continues broadcasting to the others. Effectively, feedback

*I leave the so-called audio-passive (AP) installations out of consideration because I believe that active responses by the learners followed by unambiguous feedback from the programme are essential phases in language laboratory work. Audio-passive equipment does not cater for this; it is really nothing more than a multiple-station listening device. This does not invalidate its use in language teaching, but it makes it irrelevant to our present topic.

must be provided by the programme itself in the third phase of each drill item.

In the case of an audio-active-comparative installation the optimum strategy is individualised learning. Each student works at his own pace, possibly even on a unique tape; intercom between learner and teacher involves no loss of lesson content. While feedback is provided by the programme the learner can conveniently refer to the teacher for further elucidation.

One problem with standard language laboratory equipment is that the programmes have to be linear. While it is possible for the learner to go more slowly, by repeating frames or increasing the pauses, it is not practicable for him to go faster, although the incorporation of variable speed control (VSC) has been proposed as some kind of solution. Similarly, a random-access record/playback unit is now possible but it is not readily available, and, in any case, computer technology is involved. In short, a branching programme cannot be offered with the normal equipment.

Advantages of language laboratories

A summary of the traditional arguments in favour of the use of language laboratories must suffice as a further basis for our projections about the computer in language teaching. [2, 3, 4, 5] Let me comment, however, that many of these "advantages" have proved to be no more than pious hopes.

1. All the learners in a group are actively involved with the language for the full time of the lesson.
2. It is possible to set up one-to-one interaction between teacher and learner (or two learners) without interrupting the rest of the group.
3. Wherever the learners may be seated, all can hear the lesson material equally well.
4. More than lip-service is paid to the notion of the primacy of the spoken language.
5. The voices to which the learners are exposed on the tape can be native speakers selected for desirable speech qualities, such as accent, and a rich variety is possible, all of which will enhance listening comprehension.
6. The quality of presentation remains constantly high because the machine does not become tired.
7. The isolation (in the booth and/or as a result of wearing headsets) provides a sense of security and low risk of embarrassment, encouraging spontaneity.
8. The individualisation encourages concentration, resulting in better learning.
9. Each learner works at his own best speed.
10. Providing the programme is suitable, self-instruction is possible.
11. The programme provides immediate correction and this feedback, where it is positive, provides reinforcement.
12. The comparison phase allows for self-evaluation.

13. A rich variety of the best programmes at different levels is available.
14. The approach is learner-centred although it can be teacher-directed.
15. It reduces the effect of poor teaching.

Halliday [6], writing in the sixties, summarised the positive side of the use of language laboratories and associated aids in these words:

Language laboratories and audio visual techniques can make the teaching of languages more successful, more rapid and more interesting than it is without them; moreover they carry no threat for the teacher.

Even in those halcyon days the threat of teacher resistance needed to be headed off with the assurance that he need not have any fear of being replaced by the machine!

(Perhaps I could mention as an aside that I do not entirely hold with these "comfortable words" to teachers. I am reminded of the description of the presentation style of some lecturers as the transfer of information from the professor's notebook to a student's note-book, *bypassing the minds of both*. In such cases the teacher probably deserves to be replaced, and those of our profession who look askance at the computer, should search their consciences to see whether their resistance to it is not a rationalisation of their legitimate fear that it could do their job better than they are managing it.)

Application to computers

To return to the main theme of my discourse, however, we may ask how many of these arguments in favour of language laboratories would hold at least some water for computer assisted language teaching.

In terms of sophistication one may be tempted to draw a comparison between a full-scale AAC language laboratory and a large capacity mainframe-based system like PLATO on the one hand, as against a simple AP device and a small capacity micro unit like the ZX81 on the other. This would be a mistake, because although there are features which language labs and educational computers have in common, their main characteristics which can contribute to language learning are grossly disparate. While it might be correct to say that computers can do for the secondary manifestation of language in the form of print or writing what the tape-recorder does for the primary spoken form, *that isn't all that it can contribute*. We should bear this in mind as we check off those fifteen advantages claimed for language laboratories against computers' features.

1. Given enough terminals, the "all are active" claim also holds. One could argue that this is also true for a class working from books. Ultimately it is the kind and quality of activity which makes the difference.
2. Particularly when given a network (which is perfectly possible even with average micro's) the one-to-one interaction between teacher and learner (or two learners) is available.
3. Given individual displays, all can see the lesson material equally well.

Because 4 and 5 are concerned with spoken language a meaningful comparison is not possible

6. The computer doesn't tire either, and the way it presents material in the morning will not differ from the way it does it in the evening.

- 7 Individualisation can likewise provide a sense of security. There is the added advantage that your neighbour can't even hear how you responded.
8. Individualisation encourages concentration.
9. Progress is self-paced.
10. Self-instruction is the optimum mode.
11. Immediate feedback is provided, but more than that, cues or prompts, and backward or forward branching can be incorporated.
12. Continuous self-evaluation is a major feature.
13. Different programmes at different levels are available.
14. The approach is learner-centred.
15. The effect of poor teaching can be countered.

There are a few additional "advantages" for the teacher which are often quoted:

16. He is freed from tedious drilling, marking and record keeping.
17. A much bigger pupil-load is possible without sacrificing quality. One refined programme can teach innumerable pupils.
18. Supervision is reduced because the system is cheat-proof.
19. Programme-writing and user feedback are good professional training both in terms of content and method.

We shall have to return to some of these points, if only to show to what extent they are also "pious hopes". Generally speaking, however, it isn't difficult to make out a good case for using CAL in language teaching, just as can be done for the language laboratory.

The truth about language laboratories in South Africa

Elsewhere I have reported on a recent survey into the acquisition and usage patterns of language laboratories in South Africa over the past twenty years [7]. Two of my findings in particular are relevant to our discussion.

1. Although several schools (both primary and secondary) were among the early acquirers of language laboratories, the level of what I call 'disengagement'* has been very high. I have records of seven installations which have been dismantled and an equal number standing unused. The picture at this level is one of almost complete disillusionment with the equipment and the approach.

* 'Disengagement' suggests a diminution of enthusiasm for and a withdrawal of involvement with the approach, leading gradually to a dormant state, and, eventually to complete abandonment, and frequently to dismantling.

2. While 'disengagement' is not a significant feature at tertiary level (the contrary has generally been the case!), a different kind of disillusionment is evident. What the advertising world calls 'brand loyalty' does not seem to have been a strong consideration, because 13 out of 17 institutions which replaced older installations opted for a different make, while a majority of those which expanded their facilities likewise changed their 'brand'.

It must be borne in mind that laboratories installed in the early years (1960-1968) were invariably based on modified domestic recorders, which were not robust enough to stand up to the heavy wear and tear of language laboratory operation. This accounts for a lot of the early disappointments, particularly at school level, where in-house technical back-up was not available. Nothing is better designed to frustrate and ultimately disillusion even an enthusiast than the constant breakdown of the hardware.

The reasons for the lack of 'brand loyalty' are fairly easy to find. Of the twelve makes placed in institutions in the first phase (until 1968) only five remained in the market thereafter. A feature of the early phase was that all but one manufacturer's products were handled by agencies, some of whom subsequently went out of business while others discontinued the product.

Surviving manufacturers soon tooled up for the second generation of equipment, which was purpose-designed and more robust, and much of it is still operative. The third generation, based on the compact cassette, achieved good sales in the middle and late seventies, while the latest models, incorporating limited micro-technology, account for a peak in sales last year.

What had happened, then, was that at the outset a large number of models were being marketed by a wide range of firms. Back-up service was generally poor, and no training of teachers beyond the basics of operating the hardware was offered. The salesmen, in fact, caused incalculable harm to the language laboratory approach by their unmitigated pursuit of hardware sales. Software was largely unavailable, especially for the indigenous languages, and it was not until 1973, a dozen years after the installation of the first lab, that courses in programme writing began to be offered. By that time, as far as the schools were concerned, the damage had been done.

A comparison with computer sales

In the *Sunday Times* (Johannesburg) of 29 December 1981 the following report from Colin Bower appeared:

Bad after-sales services in the small-computer industry has resulted in the Business Equipment Association's deciding to establish a computer dealers' division to set and monitor standards within the industry.

Another spokesman for the computer industry is reported to have said:

"In one instance, a purchaser paid for a computer only to find that the software for the programme he needed hadn't been written ..."

If this is true, it looks as if the same misdemeanours are being perpetrated by some computer salesmen as was the case with language labs' twenty years and less ago.

In such a climate the expectations of language teachers (as against their

scientific colleagues) are likely to be highly ambivalent. There is the chance that the gullible, not really grasping the implications of it all, are persuaded by the glib tongue and slick demonstration. The 'chalk-and-talk' traditionalists, on the other hand, will rationalise the genuine potential advantages out of mind so that they may be spared the discomfort of changing their ways. While the former are in for a let-down, which will ultimately turn them into soured anti-innovationists, the latter, usually having higher status in the hierarchies of power, deny language teaching the considerable benefits which can flow from the incorporation of CAL and CML. [8, 9, 10]

Reasons for 'disengagement'

In the language laboratory survey, some arguments were repeatedly put forward by teachers as explanations for disengagement. They fall into four main categories: technological, economic, methodological, and socio-psychological. Many of the arguments generalise more or less convincingly to CAL.

Technological factors

Failure

The most frequent argument in support of 'disengagement' is technical breakdown. As mentioned before the tape-recorders built into first generation language labs were not robust enough and it is easy to understand why these failed so soon. To this can be added the fact that many manufacturers quickly stopped producing early models and soon afterwards discontinued the provision of spare parts for them.

The euphoria of the early days often clouded the technical requirements which should have been considered at the time of purchase. Most equipment will run well initially, but after a while (once the guarantee period has expired) provision for increasing allocations for repair and maintenance must be made. Many institutions, particularly schools, failed or were unable to take such precautions.

The computer, of course, operates in a quite different technology. Moving parts are in evidence only in peripherals like disk drives and printers. The temptation, therefore, is to ignore technical failure as a potential cause for shut down. Down time, however, is a stark reality of the computer world, and it isn't really funny to add that the bigger they are, the harder they fall. But the littler ones, like the stand alone micro's, are by no means free from problems. Since the number of people who are dependent on a micro is relatively smaller, the effect of a crash is less obvious. In a network or laboratory using several units one micro down will not stop the whole operation, although it can cause inconvenience.

Obsolescence

The rapidity with which computer technology is advancing is likely to exacerbate a chronic problem with educational hardware : that it reaches obsolescence before it is worn out.

In the case of the language laboratory we have seen four distinct "generations" The first was the networked domestic open-spool recorders or dictating machines followed by the first purpose designed, cumbersome open-spool equipment of the late 60's. Better tape technology and other improvements lead to the third generation based on the compact cassette, which has since been improved upon by the introduction of microprocessor technology. I suspect that the fifth generation will integrate computer technology. (I have information about one big manufacturer's progress in this direction).

Premature obsolescence frequently has a detrimental effect on the attitudes of actual and potential users. When teachers have to struggle with outmoded hardware while they read about (or worse still, see) more sophisticated equipment, their motivation tends to sag and the potential for disengagement is increased.

Complexity

A language laboratory - even an AAC installation - is not really difficult to operate, although the mass of buttons, knobs and switches at the teacher's console may initially persuade to the contrary.

It has taken some manufacturers a while to realise that these masses of controls actually put off the teacher. All kinds of not really necessary innovations were added to enhance the product, each adding a few more control panels to the console. The wiser manufacturers have at last gone for simplicity at the teacher end, removing the less frequently required functions out of immediate sight.

Computers are much less complex in appearance. The keyboard is reminiscent of a typewriter and the video display monitor looks like a television screen, all reassuringly familiar to the teacher. Let them play a few games or run some simple interactive programmes, and they are persuaded of the computer's usefulness until the matter of programmes is raised (about which we say something more below).

Economic factors

Initial outlay

An AAC language laboratory will cost between R1000 and R2000 per student position, or in the region of R50 000 for a typical installation. The prices for computer facilities (suitable for CAL) cover a much wider range because considerations such as size and power, flexibility, sharing, siting, etc. all affect it. At the bottom of the range it will cost in excess of R2000 to provide one stand-alone micro on an outright purchase basis. The cost of the other extreme, that of a mainframe-based system, with multiple terminals is astronomical, even on a rental basis, and few institutions can consider such expenditures in the present financial climate.

While the cost of computing equipment has come down in a most gratifying way of recent years, at last putting the facilities within range of at least some institutions, prices are still too high for anything like a desirable coverage to be achieved. Institutions which cannot afford language laboratories - i.e. the vast bulk of primary and secondary schools, and many colleges - will certainly not be able to go in for computer assisted language teaching on any broad scale. The only hope is that the language teacher can get a share of the equipment installed primarily for use by other subjects, which is likely to prove a very poor second best.

Maintenance and repair

During the "golden years" between 1964 and 1967, when there was an upsurge in the acquisition of new language laboratory equipment in South Africa (29 AAC laboratories were installed in those four years) these were distributed among ten different makes. The next four year period (1968-1971) found five of these still selling. At present only three makes are still being successfully marketed (with one of them holding +80% of the sales).

If the same pattern repeats itself in the case of educational computers - and I see every indication that this will be the case - then we should try to ident-

ify the products and their distributors which are likely to leave the market place after the first flush of excitement has died down.

One of the features of the micro-computer scene at present is that almost anybody who has or can get hold of the appropriate trading licence is getting in on the act of selling them, from the little radio shop round the corner to the supermarket just up your street. The question is, will they still be there when your ageing computer needs attention? Budgeting for an increasing amount per year for service and repair is in itself not enough to ensure the continued operation of your equipment.

In the case of mini's and mainframes the risk of being abandoned is much less, obviously. If there is any golden rule to ensure reliable back-up, it would probably recommend that you buy well-known makes from recognised dealers of long standing.

Personnel

While the operation of terminals or stand-alone micro's does not call for particularly skilled personnel, allowance should nonetheless be made for designating, training and compensating in terms of workload an administrator/operator particularly if multiple installations are considered. In the language lab. experience, this task was too frequently simply tacked on to the existing workload of one of the teachers, which, because it was rather unfair, didn't lead to lasting enthusiasm for the approach. Allowance should be made for paying such a person.

Personnel requirements for the programming side of the operation will be dealt with below.

Methodological factors

Language learning theories

We must not forget that the language laboratory is a legitimate offspring of the programmed learning movement [1], a child of its time, when behaviorist learning theory was the vogue. In their earnest attempts at enhancing stimulus-response bonding course-writers of the day produced reams of rigidly structured pattern drills, most of which revealed a sad lack of imagination. I blush with shame when younger colleagues discover some of my published efforts from those 'golden years'. They were so predictable, so repetitive, that I shudder to think what they did to the already cowed minds of my pupils.

Edward Stack [11] categorized and labelled a large number of drill types, all attempts to elicit responses in a more interesting way. While their use did provide a semblance of variety, they failed to break the mesmeric trance into which the learners lapsed, a state which Julian Dakin [2] aptly called the "tum-te-tum effect". The cause of this problem lay in the behaviorists' insistence on programmed learning's 'golden rules', three of which Stack listed as:

1. Teach only one new thing at a time.
2. Keep the utterances short.
3. Establish and hold a pattern for at least eight utterances.

While it is true that language labs, like other teaching aids, "are strictly neutral" [13], it seemed as if there was "a strange alliance between the adherents of the time-honoured grammatical and translation drill methods and the exponents of self-instructional techniques and devices" [14]. Notwithstanding all the innovations introduced into language lab exercises, the overall impression remains of a place where language drilling takes place, albeit of the oral variety.

This fact is in uncomfortable contrast with the frequently expressed (although less seldom practised) emphasis on the acquisition of 'communicative competence' as an objective in language teaching.

The currently preferred approaches in the teaching of second or foreign languages recognise the need for meaningfulness. The learner is to be surrounded by a rich linguistic environment from which he or she will be able to abstract both the lexicon and the syntax he requires. Put that way it does sound a bit as if we acquire linguistic competence by osmosis, suggestive of an effortless process. The point is that in situational, functional or communicative approaches the criteria for ordering what shall be presented (or taught) at which stage, no longer have to do with the perceived degree of difficulty of the vocabulary or structure, but rather with what the learner will want to (or need to) do with the language he is studying. While the course-writer or teacher using a grammar-translation, structural or linguistic approach starts off by presenting that which is simple for the learner to grasp, the modern writer or teacher following a communicative approach will give priority to that which is immediately useful. This may mean different starting points for different learners.

What, you are entitled to ask, does that have to do with the use of computers in language teaching? You may want to echo Turner's comment about the neutrality of hardware, and you may say that the teacher will ultimately decide how he chooses to use his aids, and what material he will present through it. This is true, at least in theory, but it is also very much a pious hope. The language laboratory experiences of the past show this to be so.

Very few teachers are really free to select their approach or their materials. A number of influences impinge on them which will direct what and how they teach. Not the least of these has to do with official or unofficial policy imposed from somewhere above. (We look at this again a little later on.) Naturally, the methodological fashion of the day, taken in during training, through contact with others, or even (but rarely) through further study or reading, will help to shape his style and preferences. But most of all the teacher will be steered into a particular approach by a set of people whom neither he nor most of his superiors can control - the textbook writers and their publishers.

Textbooks and programmes

The sad demise of the language laboratory at school level came about largely because of a shortage of suitable software. In the South African context this starvation was even more acute. Most installations in schools were intended to contribute to the teaching of indigenous languages, and, with the exception of English, materials for teaching these in the language lab were (and are) in short supply or not available at all. After more than twenty years of language labs in South Africa there is still no locally produced textbook for school level which acknowledges the possible existence of even simple AA installations. Since South African teachers are notoriously textbook bound, it isn't surprising therefore that, with a very few exceptions, the thought of using language lab techniques simply does not arise for them.

The publishers and those who write for them cannot be blamed for this situation either. They are, after all, in the business to make money. To survive they have to monitor the market's demands and produce that which is seen to meet the needs. Innovation is expensive and risky. By itself that corner of an al-

ready limited market which does involve language laboratories is too small to warrant the cost of publishing specifically for it. Consequently the vicious circle remains unbroken.

It is important to notice that those few local firms which do produce record or tape based language materials aim their products not at the schools, nor even specifically at educational institutions, but rather at the man and woman in the office or the home. Their publicity blurbs make this abundantly clear, and yet institutions have to fall back on this often unsuitable material.

The computer perspective

The claim that educational hardware is neutral and can be used in support of any teaching approach must be seen for the myth which it is. Hardware is dependent on software, and it in turn depends on what has whimsically been called *underware* - all those unseen influences that give shape and form to the materials. The way a language laboratory, for example, can be used by a teacher is limited not only by his or her own ability and preferences, but also by the available software, and these constraints are in turn influenced by theoretical and practical considerations.

Does the situation promise to be any different for CAL? Because the potential for placement of micro-computers in schools is very much more promising than was the case with language laboratories, can we expect a better deal?

If we were considering CAL in general, and not specifically computer assistance in language teaching, I might be persuaded to respond much more hopefully. Computers are coming into education at all levels - there is no denying that. They are going to revolutionise administration, the curriculum is going to include practical and theoretical courses in computer operation, awareness and science, and many general subjects (not only the sciences) are going to benefit from them. The role of the computer, however, will be most obvious in the area of straight data processing. Teaching by and with the machine will evolve very much more slowly, because conditions similar to those which influenced the scope of the language lab (and other teaching hardware) will apply.

Influence of programmed learning

A look at the courseware currently available for CAL in the areas of language teaching shows clearly that programmed learning has made a comeback. Admittedly the narrowly Skinnerian linear programmes with their insulting small steps have mostly been ousted by Crowder-type branching materials, and the introduction of learning-management features (such as score-feedback and norm-development) give a souped-up impression to them, but at heart many of them are sophisticated versions of the old book-type programmes; the computers act as high speed page turners.

I would not want the above comment to be interpreted as negative criticism of CAL. The point I want to make is that, by whatever name it may be known, this kind of teaching material is firmly based in behaviorist theory. And again I would not want that statement to be misconstrued. After thirty years in education I am enough of a pragmatist to acknowledge the efficacy in many situations of good old conditioning.

What worries me is that the preponderance of this type of material may blind teachers to the vastly wider scope of CAL. In much modern educational writing dealing with language learning, the language laboratory is given scant attention because by association it is seen as being a behaviorist tool - which, of course, like any other teaching machine, it is, although that isn't all that it is!

Today's language learning/teaching methodologies draw their rationale from theories which stand over against behaviorism. The communicative approaches are cognitive, not behaviorist. They credit the language learner with an ability to abstract from his linguistic environment. Conditioning may play a role, but only a small one, and at a low level.

Over the years programmed learning - in its many different presentation guises - has been the target of numerous broadsides and sniping attacks, to the extent that many educationists were prepared to declare it dead and buried. But now, Phoenix-like, it has risen from its own ashes to reappear in the classroom encased in the very presentable form of the computer. We must not be surprised, under the circumstances, when we find the whole debate being reopened. The repetition of all the old pro's and cons is inevitable, and polarisation for and against may well extinguish the sensible pragmatism and eclecticism which has become a feature of language teaching. Blind, unyielding partisanship and dogmatism on the part of either side will not benefit the language learner very much.

Individualization vs group learning

More than twenty years ago a correspondent in the *Times Educational Supplement* [15] criticised the attempts to isolate learners from each other in language laboratory booths as being counter-productive in terms of current educational values. He wrote :

Teaching machines and language laboratories break down the cohesion of the class and present the teacher with separate pupils for individual instruction at the very time when the nature of our society demands that education should be a collective endeavour.

Some of the reactions to the De Lange Report would seem to indicate that the kind of collectivism the correspondent has in mind is not necessarily favoured by the whole corps of teachers, but the fact remains that language is the very epitome of interactive social behaviour. We say *vs* teach language for communication - which suggests at lowest a two-way interaction - and then we isolate the learners and proceed to use individualised instruction to achieve it! If this criticism can be levelled at language laboratories, it is all the more applicable to the computer.

Listening and speaking vs reading and writing

Language teaching in South Africa suffers from a heavy emphasis on reading and writing at the expense of listening and speaking. The disproportionate allocation of marks to the written responses in examinations ensures that aural/oral control is not highly developed. Although we all pay ardent lip-service to the primacy of the spoken language, the class and homework activities which we generate have a heavy bias in favour of reading and writing.

The language laboratory was supposed to set this right, by giving all the pupils the opportunity to hear and speak the target language for the full duration of a period. However, assuming that a language lab is available and a teacher (being enlightened and persuaded that oral fluency is of some consequence) integrates its use into his teaching strategy, we then have the problem of monitoring - the systematic listening in to and helping each pupil as he works through the tape. I maintain that this is the most important function of the teacher in the language laboratory, and my observations indicate that it is ineffectually applied.

Monitoring is very boring. The teacher knows the potential mistakes and finds it easier to deal with them in the open class, rather than with each individual learner as he commits the error. There are, of course, those teachers who

pretend to monitor while they are in fact marking, or preparing for the next lesson, or reading.

The case for the computer in this area is both better and worse. Because the coursewriter can build in loops to deal with many errors, there is a guarantee that all of those users who make anticipated mistakes will receive appropriate attention. This does not cover the "spontaneous" mistake, of course, but the chances of it not being flagged as a mismatch are minimal. In these terms, and at the level of the secondary manifestation of print, the computer cannot be improved upon except by a live teacher in a one-to-one or small group context.

It is possible - at considerable expense, of course - to let the teacher into a network of terminals (or linked micro's) so that he, in addition to the feedback and branching which are integral to the programme itself, can provide on the spot live intervention, in a monitoring mode or upon call. Moreover, a programme with built in management facilities can provide an absentee teacher with instant information about an individual's or a whole group's progress. The machine, in fact, does a lot of his marking and record-keeping for him. In this area the computer's potential outstrips that of any teaching machine, including a sophisticated language lab.

There are interesting speculations and exciting reports in the journals and magazines about voice synthesisers - and I have no doubt that they will be a practical reality in my lifetime. But for the foreseeable future (to borrow a favourite phrase from a politician) that possibility should not be taken into the present account. Within the scope of the present technology, however, an interface between a conventional audio source like a taperecorder and a computer is possible, and I believe that this will overcome the criticism that the computer can only deal with the printed word. Admittedly the computer will not yet be able to evaluate the learner's spoken responses - only whatever he types in on the keyboard or inputs via a paddle, pen, tablet or touch-sensitised screen can be treated in that way - but the student will at least be able to listen and respond to audio stimuli as in a language lab.

Here we have another argument which gainsays the notion that educational hardware is "neutral". There are constraints inherent in all equipment, and the computer is no exception. In the case of the language lab one such constraint is the fact that its programmes can only be linear, and, unless you link in to a display source (whether book or screen), stimulus and response will have to be spoken. Conversely, in the case of the common computer, unless you link in to an audio source, stimuli will be visual (letters, symbols, graphics) and responses usually typed, written or touched, but not spoken.

The way constraints mould the form of a programme is well illustrated by a German course called *Apfeldeutsch*, where the lesson material, in the main, is provided through printed texts and on audio-cassette, and exercises and test on floppy disc. A problem arose, however, with the student responses when capital letters (all nouns are capitalised in German) or the 'umlaut'-diaeresis were needed [16]. In the courseware for beginner Afrikaans which we are developing the same problem has arisen in terms of the 'deelteken' (diaereses), 'kappie' (circumflex) and accent marks. In the case of text displayed on the screen we can overcome the problem by setting these symbols in an otherwise blank preceding line (forcing one to interline right through the programme, for appearance sake), but in the student responses there is no way around it.

While the alternative use of traditional keyboard values for particular computer functions probably does not cause difficulties when a computer is incorporated into the teaching of other subjects or for conventional computing, in language teaching it does present problems. At the programming end most of these diffi-

culties can be circumvented, in fact, but this requires levels of expertise which the ordinary language teacher does not command. Most of them will be dependent on an author language (eg PILOT) and working on a micro to boot. Here the problems are inescapable.

Training - teaching and programming

An argument frequently put forward by teachers to defend their not using language laboratories (although these are available to them) is that they don't know how to use them properly. The implication is that the equipment is complex to use (already dealt with above) and that special skills are needed to teach in the laboratory and to programme for it. When it is pointed out that training is readily available* the majority of them will find some excuse for not attending. (We look at this resistance under Socio-psychological factors below.

Learning to operate language lab equipment is not difficult, and integrating its use into one's overall teaching strategy is largely a matter of planning. Programme writing and production does require some specialised knowledge, but experienced teachers do not usually have much difficulty in grasping the approach and techniques. There is extensive literature on the topic, and many good examples are available.

The argument that programming is difficult holds little water, but the complaint that it takes so much time is valid. Every half hour lesson in the lab will need at least 2½ hours of preparation and production time. To keep a language lab maximally active during a normal school week would call for a minimum of 100 man-hours, and in the case of tertiary institutions with longer teaching days this could be doubled! Where language teachers are not compensated with free periods or a reduction of extra-mural commitments, they will obviously not be able to meet the demand for lesson material.

In the case of the computer the validity of all these arguments is considerably magnified. A computer is more complex to operate than a tape recorder. Not only must a user be familiar with the keyboard (albeit in a two-finger style), but he must also know a number of essential routines - and quite obviously the teacher's familiarity must exceed the skills which the students will require to run the programmes.

When it comes to programming - and someone will have to do that for the indigenous languages - the situation is much worse. If teachers complain about the demands made on them in programme writing and production for language labs, then they are going to find it absolutely impossible in the case of computers. It takes a long time to acquire the basic skills to produce courseware, even with the assistance of powerful authoring languages. There are, moreover, distinct disadvantages to working within the constraints of such programming aids, and sooner or later the need to learn to programme in BASIC or a similar language becomes overwhelmingly strong.

Training people to write language programmes for computers, assuming that they have the necessary knowledge of the target language and linguistics, requires a lot of time and dedication, both of which will be found to be in short supply among the run of the mill language teachers. It is true that getting involved with computers is a lot like eating peanuts: it is almost impossible to stop,

*The South African Association for Language Teaching (SAALT), sponsored by the largest distributor of language lab equipment, conducts one or more courses each year. My own department at the University of Natal, in cooperation with the Extramural Studies and Extension Unit, offered an intensive course recently, and this will probably be repeated bi-annually.

and many colleagues who have been bitten by the bug have developed distinctly anti-social habits, but even with their kind of enthusiasm the time it takes to produce even an unpretentious single period lesson, free of bugs, is more than double the time needed to produce a language lab lesson.

Integration

In most institutions language labs serve more than one language department, and this means that specific periods have to be allocated. The result is that "language lab" is perceived by the students (and by many teachers too!) is something apart from the normal teaching interaction. Elsewhere [7] I have commented on the detrimental effect that this "tacked on" impression has on the labs' effectiveness, but it is something that teachers and students have to live with because not every teacher can have his or her own electronically equipped language classroom.

It is generally agreed among language lab teachers that where timetable schedules have to be enforced an ideal sequence for the integration of language lab sessions is the pre-lab/lab/post-lab arrangement, in which the learners can be prepared in the first lesson for what will be practised in the lab and contextualised in the third lesson. Allowing for periods to cover network and composition this would be equivalent to one lab lesson per school week.

Usually the arrangement for integrating language lab sessions into a course has to be a compromise because of timetable difficulties. Selfstudy (not supervised by a teacher) during free periods or after normal teaching hours is a solution sometimes adopted, but this must be considered second best because monitoring by a teacher or teacher-assistant is essential if the full benefit is to be derived from a language lab session. [17]

How can CAL be integrated into the average language curriculum? That will depend largely upon the hardware available, of course. With a multiple-terminal network a definite number of periods can be assigned, much on the one-in-three basis mentioned earlier. Where the system is dedicated to CAL, as is the case with PLATO, for instance, it will be possible for a student "to get a seat" once or twice a week for a particular language course. Where the system has been installed primarily to provide facilities for students studying computer science, statistics or suchlike subjects, the occupancy of the terminals is such that students required to work through CAL components in other subjects cannot be accommodated. The only answer here is to set apart a number of terminals (perhaps located in the language lab area) specifically for CAL use.

There are two problems with such systems. Firstly, there is practically no suitable courseware available to run on them, which compels one to produce one's own materials. Secondly, they require to be programmed in a (computer) language that may be difficult or at best time-consuming to learn, which will surely deflect many potential teacher-users.

For now and the immediate future most educational institutions, in any case, will have to be satisfied with one or a few microcomputers (if any at all), to be shared by several subjects and the administration. In addition to students using them to complete their assignments, staff need to be able to work on them to programme new material - and both will have to compete with the Star Wars, Chess, or other games.

Socio-psychological factors

This is a delicate area, but one which more than any other factors, singly or in combination, is likely to smother effective use of computers in language teaching.

In many of the interviews that I had with language teachers at institutions which have grossly underutilised language laboratories it was obvious that pressures to involve themselves with the equipment were not severe. They perceived little coercion (neither overt nor covert) from superiors or peers. On the other hand, any burning desire to get to grips with the approach was similarly lacking. Even mild enthusiasm for it was patently absent. This Laodicean lukewarmness towards innovation would seem to be a typical characteristic of teachers. It is not a case of complete ignorance, because they are aware of alternative strategies and approaches, but they remain aloof from them. Generalising to other institutions, it strikes us that the bulk of language teachers must be considered to have this kind of attitude: not unsympathetic, but largely inert. And like the tripartite division of presentday white South African politics, there are small, rather vociferous groupings on either side of this majority. One of these groupings, the militant resisters, provides a home for the cyberphobes* as well as the chalk-and-talk conservatives.

Callahan and Clark [8] characterise these three types as:

- (1) "Creative teachers, (who) perennially, have attempted to adapt their classroom behaviour to new knowledge as it has emerged...",
- (2) "More pedestrian practitioners, lacking the genius or the drive of the teacher-artist, (who) have attempted to keep pace by developing into 'band-wagon' followers...", and
- (3) "Factions of experienced teachers (who) have resisted change, opting instead for a perpetuation of everything that has previously met with success".

It has been pointed out by House [18] that another reason for the resistance to innovation is that teachers "remain isolated in classrooms within schools, which does not enhance the diffusion of new ideas within the profession." In an attempt to overcome this situation conferences are frequently organised to disseminate the latest ideas and information and to demonstrate new techniques, equipment and materials. A tally of the type of people who attend these gatherings, however, invariably shows a preponderance of academics, administrators, trainers and planners, but relatively few grass-roots teachers - unless some kind of official persuasion has been applied. Dissemination is not much enhanced in the process.

House categorises teachers and the way they are affected by and affect innovation in terms of three types :

- (1) Susceptibles, who may get a disease,
- (2) Infectives, who can communicate it, and
- (3) Removals, who have it, but cannot communicate it.

He then argues :

If a teacher were 'infected' by an innovation it would be difficult for him to pass it on except to teachers in his own school who would, in turn, be isolated from other professionals. The teacher is, in effect, a removal or passive adopter with little chance of affecting anyone else The very structure of the school system prevents an innovation pandemic

The effect of the "natural conservatism" of teachers and the "lack of organised provision" [19] are thus further compounded by a counter-productive ethos. Such sociological explanations of the causes of resistance to educational innovation might be seen to imply that individual teachers cannot really be blamed for the

* "Cyberphobia" is defined as "an extreme anxiety produced by dealing with a high-technology computer system". Sanford Weinberg, quoted by Rachael Wege [20]

inertia. But there are personality factors involved which contribute to the state of affairs.

In the case of almost every operative language laboratory (at whatever level), I found one individual or a small group of teachers with enthusiasm for the teaching of their language, as opposed to the frequently dull, "its a job" attitude of the rest. Sanction or encouragement from above was invariably in evidence, and seemed to nurture the impetus.

Administrators of institutions with dormant language labs. often referred to the departure of a particular member of staff as the turning point. That their or their colleagues' attitude towards this person's involvement with the equipment might have contributed towards their departure was seldom acknowledged.

Similarly, teachers at institutions with operative installations often recognise the arrival of a particular senior person as the event which vitalised them. It seems that the presence of both is a precondition for success.

Staff mobility is an important factor in the waxing and waning fortunes of language laboratories. Moreover, it seems to be a characteristic of the successful operator that he is not only enthusiastic, but also ambitious. If, therefore, he does not receive the recognition for his enthusiasm which he considers he deserves, the result is likely to be a move to another environment.

Some institutions - particularly schools - seem to have been (at least partially) falsely motivated in the initial acquisition of their language laboratories, by a kind of educational one-upmanship. Because the school down the road or over the hill had bought or been given an installation, they too should have one, and preferably something more sophisticated. In this way many AAC laboratories found their way into institutions which would have been better served by less complex AA equipment.

All these factors readily generalise to the case of computers in education. A fortunate fact is that the computer has a much wider appeal and usefulness than the language laboratory, and should one or other teacher or subject lose interest in it, the chances are that the vacuum will be filled immediately. Nonetheless, careful consideration must be given to all the factors: the total climate of the institution, encouragement for and freedom of its staff to innovate, the personalities of the potential users, and the objectives which inspire the decision to acquire the equipment. If these are ignored, it may well be found that another expensive educational toy is on its way to the "mysterious cupboard, almost always locked, (which) contains, according to legend, the school's audio-visual equipment." [21]

In conclusion

If there are any lessons from the language laboratory experience which can act as guideposts for the effective implementation of computers in language teaching they merit consideration. My experience of educational technology, however, is such that a hint of cynicism may be warranted. Much of the wheel, I suspect, is about to be reinvented, once again.

So, if that is the bad news, what is the good news?

For a start there is the undeniable fact that the computer has come to education to stay. Unlike the language laboratory and much other equipment, it is going to be such a pervasive presence that not even the most obdurate language teacher will be able to ignore it. To what degree it will contribute to language learning is going to depend on many factors, several of which have been touched on in the foregoing.

Language teachers can choose to do without the help of computers, and they will probably manage to turn out reasonably competent writers and speakers, just as those who do not have the benefit of language labs, or who choose not to use them, manage to do so. The question is not whether one can successfully teach a language without a computer, but rather which aspects of the enterprise can be enhanced for the teacher and the learner.

The present generation of computers is largely restricted (by technological and economic factors) to individualised language learning. This means that such activities as reading and comprehension tests, and that other work normally done in writing, will readily con ert to it. And so it seems that while the case for computers in language teaching perhaps cannot be made equally strongly for all four skills areas, there is more than enough potential to warrant its inclusion among language teaching aids.

The notion that computers will make teachers' lives easier had best be squashed as soon as possible. It simply is not true. Neither is there any truth in the myth so beloved of salesmen, that CAL can be "a suitable educational prothetic which could extend the power and range of the teacher, enabling him to handle more students without additional effort." [22] The language lab experience has taught us that, at least.

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COMPUTER-ASSISTED LEARNING FOR TEACHER-TRAINEES OF ENGLISH AS A SECOND

LANGUAGE

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ABSTRACT

A diagnostic test set to English methodology students in the post-graduate Higher Education Diploma Course indicated that students had an insufficient knowledge of traditional grammar. This "content material" had to be supplied before the student could derive benefit from the methodology course. The degree courses which 94% of the students followed did not include a module on grammatical theory.

The De Lange Report recognizes the future role of Applied Linguistics in teacher training courses. Linguistics acknowledge the necessity of acquiring one or other grammatical system in mastering a second language. Whether in teaching a second language the teacher adopts the traditional grammar approach or the situational, notional and functional approach, he must have at his command some grammatical structure.

Computer-assisted courses can make a significant contribution to the methodology course in supplying the "content material". The student can use the computer for self-diagnostic, self-instructive and self-testing purposes.

COMPUTER ASSISTED LEARNING FOR TEACHER-TRAINEES OF ENGLISH
AS A SECOND LANGUAGE

As a lecturer involved in teacher training, I have over the past three years become aware of the academic shortcomings of those students who have enrolled for the Higher Education Diploma. I refer specifically to those students who as graduates have English as one of their major subjects and who follow the methodology of English. Entrance to this course is limited to students who have had English as a third-year subject, but, in some cases where students do not have a second teaching subject on a third year basis, they are granted permission to enter for this course with a second year qualification.

English methodology is a two-semester course: the first semester deals with the teaching of English as a second language and the second semester, the teaching of English as first language, both at high school level. Although my paper centres round the training of teachers of English as a second language, much of what I have to say is also applicable to the teaching of English as a mother tongue.

In order to teach the methodology of a subject successfully the lecturer should be able to take it for granted that the student has a basic content knowledge of that subject. This is so in certain aspects of the subject. Students who have taken English as a major subject at a South African university have, if one can come to any meaningful general conclusion, a fairly sound grasp of English literature. The young student who has gained a meritorious pass in English three is usually well-spoken, well-read and well informed about past and current literary trends. He is perspicacious and during the three-year course he has developed a sound

literary judgment. But, for reasons which I shall try to identify later, he has scant if any knowledge of the structure of the language.

Although he has a passable written and oral proficiency in English, and although he uses English with his own individual consistent "grammar", he is not able to define the "rules". He does not possess a working terminology to define why he speaks or writes in a certain manner. He cannot take language apart nor explain why some forms of language are correct and others are not. In short, he has a poor knowledge of what is usually referred to as traditional grammar.

Fifty students entered for the Higher Diploma methodology course in English this year. Of the 50 students 39 had taken English to the third year as one of the major subjects of their B.A. degree, and 11 had English as a second year subject. There were no M.A. students. Six per cent indicated that the degree course had included a language component in which they had received lectures on grammatical theory; 94 per cent indicated that their degree course had not included such a component.

Only two per cent indicated that their degree course included a course in English phonetics. Forty-six per cent had taken Afrikaans as a major which included a course in phonetics and 50 per cent of this group indicated that on the strength of the knowledge they had acquired in the Afrikaans course they could read English phonetic script.

On entering the methodology course, students were asked to sit for a test (see (1)) which included 5 subsections each consisting of 5 questions. In the first section which asked students to identify the most common parts of speech,

only 12 per cent could identify all 5 parts of speech correctly.

In the second section traditional grammatical terminology was tested. (Students were asked to identify case, voice, mood, tense). No student managed to gain the maximum mark and more than 60 per cent of the students gained less than 50 per cent for this subsection.

In the third section students were asked to distinguish between sentences and non-sentences. Thirty per cent gained the maximum mark.

Only 4 per cent gained the maximum mark in Section IV which tested the terminology relating to phrases, clauses and sentences.

Section 5 tested error identification. Only 14 per cent realized that the five given sentences were all correct. More than 32 per cent of the students said that 3 of the 5 correct sentences contained errors.

The average score for the test was 49.32 per cent. The three students who indicated that their degree course had included a language module had an average of 86.00 per cent.

The obvious general conclusion one can arrive at is that the student who presents himself for the H E D course has, for the purpose of following the methodology course in English, an inadequate knowledge of traditional grammar.

There is a very obvious reason for this. Unless a pure language module is incorporated in the English course, he never acquaints himself with any particular grammatical theory. Most English courses at South African universities place the emphasis strongly on literature and not on language study.

Moreover, whereas the scholar who arrived from school at the university thirty years ago had some knowledge of traditional grammar, having been taught through the old indirect method which stressed the so-called grammatical rules, the scholar who entered the first year course ten to fifteen years ago had not been given this type of tuition. In the first language courses parsing and analysis were discontinued, and in the teaching of the second language the indirect method was replaced by the audio-lingual and the functional methods. In recent years there has been a tentative return to the teaching of grammar in the high school⁽²⁾ but it still holds an uncertain position in the classroom.

Concern has been expressed in various quarters⁽³⁾ about the inadequate training teachers of English receive at university level. The report published by the Human Sciences Research Council - Provision of Education in the R.S.A. 1981 (commonly referred to as the De Lange Report)⁽⁴⁾ - recommends that "the relevance of certain degree courses for language teaching should be improved. English courses in particular concentrate too narrowly on literature." (See (4) Page 148 - 4.11.5 24). This recommendation underlines the importance of investigating the possibility of instituting an English degree course specifically for high school teachers. At present the English departments in our arts faculties offer courses which provide the foundation for a wide spectrum of professions, teaching being only one of them.

In the one-year methodology course for the post-graduate diploma in higher education, the lecturer is faced with the problem that, in order to train teachers adequately in the teaching of English as a second language, he must first give the content of the subject before he can supply the

method of teaching it. This is not the case in the methodology of literature where the student has a thorough knowledge of the content material, but literature accounts for only 20 per cent (60 marks) of the Senior Certificate second language paper.

The teaching of English as a second language (ESL) is a discipline which over the last few decades has come into its own right. It is not an offshoot or a by-product of the methodology of English as a first language (L). "Exactly the same methods cannot be used to teach ESL and English as an L₁." ⁽⁵⁾ Furthermore, we must bear in mind that to many scholars in South African schools, English is a third or a foreign language, and as the De Lange report points out "a clearer distinction will have to be made between the teaching of a second and a foreign language (and) provision will have to be made for this in the training of teachers." (See (4) P. 149) In addition the De Lange report recognizes the future role of Applied Linguistics in teacher training courses.

Over the last few decades linguistic studies have contributed considerably to English second language methodology. "It is left to the general linguist to study language in a neutral unslanted way; to study language for its own sake. He is interested in its inherent nature, rather than in its importance for something else; he has no ulterior motive." ⁽⁶⁾ But the applied linguist has an ulterior motive: namely, to use his linguistic knowledge to determine the process of L₂ acquisition and to determine the most expedient method of acquiring the second language.

D.A. Wilkins acknowledges the necessity of acquiring one or

other grammatical system in mastering the second language. "The learning of a language is most commonly identified with acquiring mastery of its grammatical structure." ⁷⁾ He groups the many approaches to the teaching of a grammatical structure under two headings: a synthetic language teaching approach in which the different parts of language are taught separately and step-by-step so that "acquisition is a process of gradual accumulation of the parts" (See (7) P. 2), and the analytic approach in which "a greater variety of linguistic structure is permitted (and in which) the learner's task is to approximate his own linguistic behaviour more and more closely to the global language." (See (7) P. 3). He sees the traditional grammar approach as a synthetic approach and the situational, notional and functional syllabuses as belonging to the analytic approach.

Whether, in our attempts to teach English as a second language, we adopt the traditional grammar approach or the situational, notional and functional approach, we must have at our command the terminology of the approach we adopt. In the case of the former the traditional grammatical terminology, in the case of the latter the categories of a notional syllabus.

The ideal situation in our methodology course would be to introduce our teacher trainees to methods of applying both approaches. We can only do so provided they have a content knowledge of both approaches. That they do not have a knowledge of traditional grammar has been corroborated and that they be acquainted with the functional and notional approach cannot be expected owing to its recent innovation in L₂ methodology.

It is in this field that computer-based instruction can make a significant contribution. It can offer a means of instruc-

tion which the student can follow in his own time and at his own pace, depending upon his ability to master the content material necessary for the methodology course.

To my knowledge no computer-assisted courses which can be used as supportive material to methodology courses exist, but I see in the computer the potential to offer a device which the student can use for self-diagnostic, self-instructive and self-testing purposes. I envisage a computer-assisted instruction course for methodology students that will have the following format:

- i) It is an on-line instruction course i.e. the student uses the terminal and receives instruction in its use.
- ii) The first set of tests are diagnostic. These tests determine whether the student commands an adequate standard of content material to enter the methodology class.
- iii) These diagnostic test indicate to the student immediately whether his knowledge of content material is adequate or not. If not, the tests offer a diagnosis of his weaknesses.
- iv) Instructional units are now presented, each unit having one objective. The student's weaknesses having been identified by the diagnostic test, he now selects the units he wants to be instructed in.
- v) There is a continuous system of record-keeping to monitor the student's strengths, weaknesses, difficulties and progress. At any moment he can ascertain what his score is and how it measures

up to the average.

This is how I envisage the role of computer-assisted instruction and learning in the methodology course for teacher trainees of English. Its feasibility has still to be proved. The possibility that on-line instruction and testing can make a very meaningful contribution to the training of teachers must certainly be investigated.

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ADDENDUM ADIAGNOSTIC TEST. H.E.D. ENGLISH METHOD COURSE

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1.0 EXERCISE ONE:

Read the following passage and say what part of speech each of the underlined words is.

Man has been fascinated by gold ever since he first saw its glitter in river beds and streams.

Gold is probably the first metal discovered by man, possibly more than 6000 years ago. Ever since, he has revered and craved the metal, mainly for its sheer beauty and the ease with which it can be worked and shaped to produce jewellery or works of art. Gold ornaments which have survived from early civilisations tell us much about ancient peoples.

- i) first :
- ii) by :
- iii) has :
- iv) it :
- v) and : (5)

2.0 EXERCISE TWO:

"Man has been fascinated by gold ever since he first saw its glitter"

- i) What is the tense of the verb has been fascinated?
.....
- ii) In which voice is this verb?
- iii) What is the case of its?

- iv) What part of speech is glitter?

 v) What part of speech would it be if the
 sentence was changed to read: "Particles
 of gold glitter in the river beds"?
 (5)

3.0 EXERCISE THREE:

Indicate whether each of the following is a sentence or not. (Place either a tick, if a sentence, or a cross, if not).

- i) Cross the railway line by the overhead bridge, please
 ii) To err is human; to forgive divine.
 iii) Violent disagreement ought to have been anticipated.
 iv) Step inside.
 v) Just leave me that sample; that's ample. (5)

4.0 EXERCISE FOUR:

Indicate whether each of the following is: a simple sentence, a complex sentence, a compound sentence, a phrase, or a clause.

- i) I am hungry because I'm tired.

 ii) Having come a long way across the veld, I am as tired as a flogged horse.

 iii) Because I have run a long distance.

 iv) Having run a long way.

 v) I am tired and I am very hungry.
 (5)

5.0 EXERCISE FIVE:

Indicate whether these sentences are correct or not. (Place a tick or a cross).

- i) South Africa expects every man to do his duty. ...
- ii) Their lives, their liberties and their religion are in danger. ...
- iii) At night their only guide was the stars. ...
- iv) Those whom the gods love die young. ...
- v) You hate her as much as I. ... (5)

AUTHORING TECHNIQUES AND COMPUTER-ASSISTED LANGUAGE LEARNING. HOW CAN THE
TEACHER MAKE THE BEST USE OF THE MICROCOMPUTER?

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ABSTRACT

Computer-assisted language learning is slow to gain a foothold in education, despite the rapid developments in micro-computer hardware. Good language-learning software is in short supply and often expensive or inappropriate to the individual teacher's needs. Unless language teachers are given the means to create their own computer courseware there is a danger they will be submerged under a deluge of hastily produced, poor quality materials before they have a chance to come to terms with the new technology and explore its full potential.

It is unrealistic to expect language teachers to become computer programmers overnight but perfectly feasible to give them training in the necessary authoring techniques to enable them to develop their own materials for the microcomputer. Software authorship is a difficult art and it is easy to fall into the trap of a drill-and-practice approach.

Authoring systems are a useful aid for language teachers but they must be selected carefully for their ease of use and applicability to a text-based subject. The writer undertakes an examination of authoring systems and other more ambitious approaches to computer-assisted language learning in order to illustrate the range and variety of authoring techniques. It is the writer's view that high quality software can be achieved only through close collaboration between programmers and subject specialists and understanding of their respective disciplines.

The future holds forth more interesting and exciting prospects, including audio-enhanced systems based on tape recorders and audio disc units. Finally, there is the possibility of the computer-driven video disc system. It is essential that language teachers seriously consider the implications of such developments and how they should approach the authorship of appropriate courseware.

AUTHORING TECHNIQUES AND COMPUTER-ASSISTED LANGUAGE LEARNING. HOW CAN THE
TEACHER MAKE THE BEST USE OF THE MICROCOMPUTER?

The microcomputer has been noticeably slow to gain a foothold in language teaching in spite of the fact that moderately priced hardware has been available for some years. The lack of enthusiasm for new technology amongst language teachers is perhaps understandable in the light of the poor results achieved with the language laboratory and the current vast range of audio-visual equipment. Technical aids can be of immense value, but they are so often unreliable and improperly maintained. Their biggest drawback, however, is that they can only be efficiently utilised if the range of courseware which can be used on them is both varied and of high quality. It is an unfortunate fact of life that advances in the development of hardware are much quicker than in the development of software. This is particularly true of the microcomputer.

There is nothing inherently wrong with technical aids such as the language laboratory, slide projector or videotape recorder and they all have a role to play in education. There is, however, a tendency for teachers to dismiss the hardware because the software is inadequate. It is foolish to be so shortsighted, and akin to dismissing the book because most printed material has severe shortcomings. Good quality teaching material is generally hard to find. Good quality tapes for use in the language laboratory are even harder to find, but it is almost impossible to find any good quality language teaching material for use on the microcomputer.

My personal view is that language teachers have only themselves to blame for the shortage of teaching materials. They are of course busy people and have little time to devote to courseware development. Nevertheless it is high time they overcome their natural scepticism and seriously considered the implications of computer-assisted language learning (1). The computer is unlikely to disappear in the near future and there is a growing danger that computers will take the initiative. The outlook is not promising: programs in which it is clear that the programmer, not the teacher, has called the tune are already on the market. Unless language teachers abandon their head-in-the-sand stance they are certain to fall victim to any unscrupulous software house whose main concern is profit rather than educational principles.

The way ahead is to involve language teachers as soon as possible in the creation of courseware (2). It is not difficult to train an experienced language teacher in the use of the computer and elementary programming - probably a good deal easier than teaching a programmer a natural language and language teaching methodology (3). A computer keyboard is no different from a typewriter keyboard, apart from a few new symbols, and if it is possible to train a secretary to use a word-processor then it is also possible to train a language teacher to write his own computer courseware.

At this point it is useful to consider what kind of material a language teacher might wish to present via the computer. The Socratic approach to learning is to give the learner a small amount of information and then to follow it with a question. In answering, the learner is forced to take an active rather than passive role and supply feedback to the teacher. This is an approach greatly favoured by language teachers, who use the question-answer dialogue extensively in oral and written work. A typical oral dialogue, say to elicit a response using the present tense of a German verb, might go something like this:

Teacher: Spielst du gern Tennis?
Learner: Ja, ich spiele gern Tennis.
Teacher: Sehr gut.

This is a type of dialogue which can work quite well in the language laboratory, with the disadvantage that the teacher may not always be there to monitor the learner's response. In the language laboratory much greater emphasis is placed on the learner monitoring himself.

In written work the Cloze test is an established means of eliciting a response. A test on the present tense of German verbs might consist of a series of exercises like this:

Question: Mein Bruder _____ Tennis. (spielen)
Answer : spielt

The disadvantage of this type of exercise, or any other form of written exercise, is that at some stage it has to be checked by the teacher, or by the learner who might consult a list of correct answers.

These two examples are not intended to be models of language teaching methodology, but for the purposes of this paper they will serve as illustrations of the type of simple reinforcement exercises which lend themselves to translation into computer-assisted learning routines. In the early stages of the language teacher's involvement with computers it is advisable to keep things simple and to postpone more ambitious projects to a time when the teacher has gained a better understanding of the computer's potential.

The Cloze test can be very effective as a computer-assisted learning routine. The stimulus is presented on the screen and the learner types his response at the keyboard - in a properly designed computerised Cloze test the learner's response appears in the correct position in the sentence. Cloze tests of this sort can appear as single sentences or longer texts. If the above example were transformed into computer form the dialogue between computer and learner might look like this:

Computer: Type the correct form of 'spielen'
in the Present Tense:

Mein Bruder _____ Tennis.

Learner : spiele

Computer: That's the 'ich' form. Try consulting
the pattern: (computer displays paradigm)
Now try again....

Learner : spielt

Computer: That's better. Now try another question....

The immediate advantage is the instant feedback which the computer supplies to the learner, in combination with the offer of relevant help. The computer begins to assume the role of the teacher, but is by contrast infinitely patient! It goes without saying that the instructions in such a test can be in English, German or any language the teacher chooses.

The computer is particularly effective in the presentation of exercises of this type, where only one or a limited range of responses is acceptable. It is much more difficult, though not impossible, to create exercises where the responses may be more open-ended, although one wonders, for example, in how many different ways a learner might respond to the question in my first example:

Spielst du gern Tennis?

So far I have concentrated on the computer as a sort of quizmaster. Generally speaking, it is not as good as the teacher in presenting completely new material, but that is a matter for further debate. Presentation strategies are, however, very important and I shall come back to this question later.

For the moment, let us consider what the language teacher has to do in order to author a set of computer-assisted learning exercises. Ideally the teacher should be able to write his own programs or at least have access to the services of an experienced programmer. It is unrealistic to expect language teachers to become proficient programmers overnight, although there is a growing band of enthusiastic linguists who have come to terms with the discipline of programming in a remarkably short time. Experienced programmers who have the time and patience to assist language teachers in the creation of computer-assisted learning routines are rare birds, so what is the solution?

The easiest way in which a language teacher can begin to approach computer-assisted language learning is to use a sympathetic authoring system. There are many authoring systems on the market but not all are easy to use and many have features which are irrelevant to those of us who work predominantly with textual material.

One good example of an authoring system, or CAL package, which is eminently suitable for the language teacher is TES/T, which was created by Rex Last, now Professor of Modern Languages at the University of Dundee, Scotland (4). The package is available for use on the Tandberg EC10 microcomputer, and as it runs under the CPM operating system it should also work on a range of other popular microcomputers. It is designed for the teacher who has no knowledge of programming and very easy to use. There are no complex commands to be learned; all the teacher has to do is answer 'yes' or 'no' to a series of questions or select options from a menu. The package allows the teacher to set up panels of information on the computer screen, containing instructions, questions or comments in response to right, wrong or specified answers. To create our sample Cloze exercise, all the teacher has to do is type:

Type the correct form of 'spielen'
in the Present Tense:

Mein Bruder "spielt" Tennis.

The double quotes indicate that 'spielt' is the required answer. When the question is presented to the learner it looks like this:

Type the correct form of 'spielen'
in the Present Tense:

Mein Bruder > Tennis.

The '>' sign indicates the position in the sentence where the learner types his answer. Any comments the teacher wishes to appear are created by selecting various options from the menu. If the learner answers 'spielte' for example, a comment might appear:

Sorry, no, that is the Imperfect Tense.
The Present Tense is required here.

Alternatively, or in addition, the appropriate paradigm could be presented for reference.

TES/T is not limited to Cloze tests. Any situation in which a textual stimulus may be presented in order to elicit a typed response is feasible. The only limitation is the imagination of the teacher.

My own package, the TEACHER'S TOOLKIT, adopts a similar approach to the authoring of computer-assisted learning material (5). A CREATION program enables the teacher to type his material in a series of panels to include introductory notes, questions, answers and comments, with the option of supplementary help notes. It is currently available for the PET, APPLE and TRS 80 microcomputers and written in BASIC. A typical question/answer panel might look like this:

Question 1	Max Lines 2	Line
Give the German for 'the car'.		1
Type the article followed by the noun:		2
Answer 2	Max Lines 5	Line
der Wagen		3
das Auto		4
der PKW		5
+Good! Der Wagen/das Auto/der PKW		6
+are acceptable answers.		7

In the above example the first three lines of the answer section contain alternative acceptable answers and the last two lines (preceded by the plus sign) contain a comment to follow a correct response from the learner. The minus ('-') sign is used to prefix comments to follow incorrect responses. The package allows the learner to consult help notes by typing the letter 'h' and the teacher can establish a hierarchy of correct alternative answers if necessary. Partial matching is an additional feature, so that if, for example, the learner thinks 'der Wogen' is the answer the computer will correct him, thus:

der W[O]gen,

the letter 'o' being highlighted. He is then invited to try again. Both TES/T and the TEACHER'S TOOLKIT allow the teacher to specify that answers may be accepted in upper or lower case and the creation of the shape of an anticipated answer. If the anticipated answer consisted of two words, one of three and one of four letters, its shape could be presented, thus:

*** ***

This helps to eliminate certain possible answers when the question may be opened.

There are many authoring systems on the market, too many to deal with in detail here. Two others may be singled out for consideration: ARISTOTLE'S APPLE (6), which runs on the APPLE microcomputer and is both flexible and inexpensive, and WATCAN (7), a new package designed by Carl Hennig, Language Laboratory Supervisor at the University of Waterloo, Ontario, Canada. The former is designed for the inexperienced user and assumes no programming expertise, whereas the latter is aimed rather at the teacher who has some experience in using computers and wishes to speed up the generation of computer-assisted learning programs. WATCAN allows the teacher to set up quite complex error diagnostic routines and actually generates BASIC code. As it runs under the CPM operating system it should be available for a wide range of microcomputers. I have seen it running on a SUPERBRAIN and it looked very impressive.

The advantage of an authoring system is that it speeds up and simplifies the process of transforming the teacher's material into computer terms. It does not, however, do anything to help the creation of the material itself. Here the teacher has to draw on his own creative resources. It does enable the teacher to avoid some of the pitfalls he would encounter if he attempted to write his own programs in BASIC. Although BASIC is the commonest microcomputer language it is notoriously cumbersome and there is no standard version. Different microcomputers have different implementations of BASIC, which can create all sorts of problems. A good authoring system will automatically allow for such problems, some of which may prove intractable to the inexperienced user. Let us consider the following program in BASIC:

```

10 PRINT "Type the correct form of 'spielen' in"
20 PRINT "the Present Tense:"
30 PRINT
40 PRINT "Mein Bruder _____ Tennis."
50 INPUT A$
60 IF A$= "spielt" GOTO 90
70 PRINT "Sorry, wrong, the answer is 'spielt'."
80 GOTO 100
90 PRINT "Well done!"
100 PRINT "Now try the next question..."

```

On some computers the INPUT statement at line 50 can cause an incomprehensible error message to appear if the learner presses the RETURN key without typing anything. On other computers the answer 'spielt' (preceded by a space) will be judged wrong. These problems can be overcome in BASIC but a good authoring system makes life a lot easier.

Eventually the teacher will outgrow authoring systems and aim at more ambitious projects. At this stage it is worth looking at an author language like PILOT or TUTOR. PILOT is available on some microcomputers and TUTOR is the language used in the PLATO and Modcomp's SIMPLER systems. As far as I know, TUTOR has not yet been implemented on a microcomputer but it is a powerful author language with some excellent features. If we were to rewrite the above BASIC program in PILOT it might look like this:

```

T: Type the correct form of 'spielen' in the
T: Present Tense:
T: Mein Bruder _____ Tennis.
A:
M: spielt
TY: Well done!
TN: Sorry, wrong, the answer is 'spielt'.
T: Now try the next question...

```

It is obviously a lot more straightforward than BASIC and uses mainly single or dual letter commands. The program can be written in a more natural, linear manner and the complexities of the IF and GOTO statements are avoided. PILOT incorporates some very powerful matching features which may or may not be relevant to language learning. For example, the ampersand ('&') sign acts as a sort of 'wild card' character and enables the teacher to allow for common misspellings. If the anticipated answer to a question was 'psychologist' the teacher could insert the following in his program:

```
psy&h&g&t
```

This would allow for a variety of misspellings. TUTOR has a command with a similar effect:

specs okspell

PILOT and TUTOR, like the authoring systems already described, allow the teacher to specify the acceptance of answers in upper or lower case or to make the computer ignore superfluous spaces in an answer. The PILOT command to eliminate spaces and convert the learner's input to lower case is very short and convenient:

PR: LS

TUTOR has the command:

specs okcap

which causes the computer to accept answers in upper or lower case. If one compares these short commands to the code which would have to be written in BASIC to achieve the same effect, then the advantages of author languages are obvious:

```
10 FOR X = 1 TO LEN (A$)
20 A$ = LEFT$(A$ X-1) + CHR$(ASC (MID$ 1) AND 127) + MID$(A$ X + 1)
30 NEXT X
40 X = 1
50 IF MID$ (A$,X,1) = " " THEN A$ = LEFT$(A$,X-1) + MID$ (A$,X+1):A
60 IF X<LEN (A$)THEN X = X + 1: GOTO 50          GOTO: 50
```

This is the version of BASIC used on the CBM PET and the above code will convert the learner's input, to lower case letters and eliminate spaces.

It must be emphasised that an author language will still take some time to learn and that it may have a number of features which are of no interest to the language teacher. Really ambitious CAL programs, which do exactly what the teacher wants, can only be created by a teacher who is an efficient programmer or by close collaboration between teacher and programmer. The latter approach has been adopted by the creators of the CLEF (Computer-Assisted Learning Exercises in French) package at the University of Western Ontario, Canada (8). It is of course an expensive way of doing things, but effective. Good software cannot be produced on the cheap. The CLEF project dates back to 1979 and is still in progress. The team involved in the project includes two programmers and a co-ordinator and the aim is to write a package of CAL programs for students of French at beginners and intermediate level.

The CLEF programs are written in BASIC and run on COMPUCOLOR/INTERCOLOR micro-computers, but there are plans to convert them for more popular machines, such as the PET and the APPLE. The programs cover the essential structures and vocabulary of modern French and are designed to be course-independent in order to attract a wide range of users. A good deal of thought has gone into each program, particularly the presentation of material. A typical CLEF routine works like this:

The student inserts the floppy disc containing his chosen program into the drive and presses the 'auto' key. It is a turnkey system so the CLEF emblem is immediately displayed and the student is offered a menu of CAL tests available on the disc. All the discs are numbered and the student can see which one he wants by reference to the handbook. The program begins with an optional grammar review, followed by a checking routine to ensure that the student is familiar with the important vocabulary contained in the program. If he knows the vocabulary he can skip through this routine very quickly - with one keystroke in later CLEF programs. The question-answer sequence follows, testing the student on the points illustrated in the grammar review. It is in this section that the thought behind each program becomes most apparent and where the CLEF team's efforts score over any authoring system or author language. Discrete error diagnostic routines pinpoint the student's errors and attempt to guide him towards the correct response. In a test on French '-er' and '-re' verbs,

which I attempted myself, the computer responded to my various (wrong) responses as follows:

Computer: Paul et Marie _____ les chansons folkloriques.

(here the student is expected to insert the correct form of the Present Tense from a selection of verbs: e.g. parler/châter/répondre)

1 Response: chantons

Computer: Attention - la termination n'est pas correcte.

2 Response: chntent

Computer: Regardez le radical du verbe. Il n'est pas correcte.

(at this point the computer opens up the response to reveal the point where a letter has been missed out)

ch ntent

Corrigez la réponse.

3 Response: channtent

Computer: Regardez le radical du verbe. Il n'est pas correcte.

(here the offending superfluous letter is underlined in yellow and the student is invited to try again)

4 Response: garbage

Computer: Non, ce n'est pas la bonne réponse. Essayez de nouveau.

So the computer's reactions to the various inputs are on the whole intelligent and useful. The teachers who have designed the program have anticipated a number of common errors, with a general 'wrong' comment in reaction to the input 'garbage', which obviously defies analysis! The student is normally allowed two attempts at each question (the above set of responses took place on separate runs) and a review of all incorrectly attempted questions takes place at the end of a sequence.

More recent CLEF programs enable the student to access the grammar review at will and call up translations of words he does not know. Colour is used extensively to highlight verb or adjective endings, to pinpoint errors or to draw attention to differences in gender - blue for masculine and red for feminine nouns. Primitive graphics may be used where appropriate, for example a matchstick man under a tree to draw attention to the preposition 'sous'. Representations of simple objects - a table, a flower, a human face or figure - are interspersed throughout the package.

Animation of words is another feature: for example, to emphasise syntactical points such as the position of the negative 'ne...pas' in relation to the verb or certain adjectives which have to follow the noun. The merging of prepositions with the definite article - 'à le' becoming 'au' and 'de le' becoming 'du' - is also presented in an animated sequence.

The results of the CLEF team's efforts are impressive and the consequence of close collaboration between academic staff and sympathetic programmers. It is in the area of error diagnostics and presentation where this approach pays off

and where the computer's full potential is exploited. I indicated earlier that in the early stages of his involvement with CAL the teacher should keep things simple. It is important, however, to avoid the pitfall of treating the computer as if it were an electronic book (9). The animated sequences in the CLEF package are an obvious example of the more ambitious presentation strategies which the teacher can attempt. This is an approach I have also adopted in my own series of German CAL programs I have created on the PET and APPLE computers (10). German word order creates immense problems for the beginner and I had always felt that it would be easier to show the learner what was happening in a sentence if the words could be seen to move. Clearly this cannot be done in a book, on the blackboard or on the overhead projector. I therefore decided to design a series of programs incorporating animated sequences to illustrate and reinforce aspects of German word order. The series includes subordinate clause word order, inversion in main clauses, separable verbs, relative pronouns, the passive voice, order of objects and attributive participial phrases. Animated sequences bring the programs to life and avoid the sterile presentation style which characterises so many CAL programs.

Another feature which the teacher can incorporate into a CAL program is the random generation of questions. This works particularly well in any routine involving numbers: for example, clock time, dates and money. It is also possible to write similar programs to handle the conjugation of verbs or the cases of personal pronouns. The advantage of the random generation feature is that it makes it impossible for the learner to become acquainted with the sequence in which questions are presented.

One argument that is often raised against the writing of dedicated CAL programs is that the teacher has to make do with the material embedded therein and take it or leave it. It is, however, possible to write the programs in such a way that the textual data can be easily amended without affecting the running of the program in general. Programs of this sort may be termed template programs, whereby the teacher with a minimal knowledge of BASIC can change line of DATA and create a virtually new program. Supposing, for example, a teacher was not too happy with the text of my programs on word order: it would be no more than an hour's work to rewrite the DATA statements in a specified format and the program would automatically allow for the new material.

So far I have concentrated on the authoring of programs to present and test points of grammar and vocabulary. There is no denying that the computer is particularly good at this mechanical sort of work, but greater imagination on the part of the teacher can reveal a number of exercises which are much more stimulating for the learner. The computer's ability to play games can be exploited, and perhaps should be exploited if teachers are to retain the attention of future generations of children weaned on Space Invaders and other arcade games. Hangman, the word guessing game, complete with a pictorial representation of the hanged man, Anagrams, Odd Man Out, Language Snap and Crosswords are certainly within the scope of a competent programmer (11). Other computer games worth investigation include the popular Adventure programs and guessing games such as Guess the Animal (12). All these games involve the use of language to a lesser or greater degree and are a pleasant diversion from the spade work of language learning.

Another interesting idea is the textual maze. A recent book, called 'Marzes', by Marge Berer and Mario Rinvolutri (13) is an excellent illustration of the principle. Essentially, a textual maze is a collection of reading passages through which the reader can select alternative paths. The book's aim is to develop the reading skills of learners of English as a foreign language. As the reader passes through the maze he is confronted with a series of texts, each one of which requires a decision. A series of wrong decisions can result in the reader ending up in any number of loops and blind alleys. The object of the game is to get out of the maze as quickly as possible. Apparently the idea of the textual maze arose in teaching business management, but it has a good deal of value in the teaching of language in an entertaining and often

amusing way. The book could easily be converted into a series of computer programs. My own experiments have shown it is time-consuming only in terms of the amount of text which has to be typed. Today's microcomputers can comfortably cope with the volume of text involved, so that is no problem.

I touched on the question of open-ended responses and the difficulty of allowing for alternative answers. One area in which responses are inevitably open-ended is translation. Even this is possible, providing one guides the student through the process step by step. Brian Farrington at the University of Aberdeen, Scotland, has experimented with the computer as a means of teaching French prose composition at university level. Students' initial reactions seem very favourable (14).

The potential of the microcomputer in the learning of languages is enormous, but teachers need to acquire new skills and imagination in order to exploit it properly. In my introductory remarks I mentioned that developments in hardware were outstripping developments in software. It is a warning worth repeating as we look to the future. If we cannot keep up with current developments then things are likely to get worse, unless we make a supreme effort. One element I have not yet mentioned in connection with computer-assisted language learning is sound - and I do not mean voice synthesis, as the quality is inadequate for normal language teaching.

One positive effect the language laboratory had when it was introduced in the 1960's was to reappraise the role of oral and aural skills. Recordings of native speakers' voices were something of a revelation for many learners and teachers of foreign languages. Current technology already allows a standard audio cassette recorder to be coupled with a microcomputer and natural human voices to be presented to the learner in synchronisation with textual and pictorial displays on the computer screen. The ATARI series of language learning programs uses this technique but the system has certain drawbacks in that the audio cassette recorder it uses has to present material in a linear fashion, whereas the obvious advantage of the computer is that it can access data randomly. Sound does, however, add a powerful new dimension to computer-assisted language learning and it is up to language teachers to consider how they should approach the authorship of programs incorporating sound.

A more promising idea is Tandberg's AECAL (Audio-Enhanced Computer-Assisted Learning) system, which makes use of an audio cassette recorder with an automatic fast forward and rewind facility under computer control (15). The marriage between the computer and this type of recorder is a much happier one and will enable the teacher to create his own dictation and aural comprehension exercises, whereby the computer monitors the learner's answers, which are typed at the keyboard, and allows him to review the recorded material at will.

My personal view is that computer-assisted learning systems based on traditional audio cassette recorders will be relatively short-lived and eventually surpassed by the audio disc unit, which is already on the market in the USA (16). Floppy disc units for microcomputers have already proved their worth in terms of convenience and access time and there is no reason why audio disc systems should not be similarly successful. The audio disc allows substantial amounts of recorded material - human voices or music - to be accessed within an impressively short time - approximately a quarter of a second. It may be some time before audio disc units become readily available and the prices reduce to a reasonable level, but language teachers should begin considering what sort of material they would like to see used on such systems. In theory it should be possible to present conversational material in this way. Certainly such systems will make it easier to present and review a variety of recorded dialogues and texts under computer control.

Finally, there is the question of the visual element, the computer linked to a videodisc unit. The present obsession of some computer scientists with high resolution graphics seems somewhat futile when one considers the quality of pictures a videodisc unit can offer. Experiments at the Ontario Institute for Studies in Education have shown how the videodisc unit can be used in conjunction with a microcomputer to train apprentices in the acquisition of technical skills (17). Clearly this has implications for the language teacher. Television has already made a considerable impact on language learning and high-quality programmes have been produced. The possibility of linking television recordings on videodiscs with a microcomputer is an exciting challenge to language teachers. Let us consider the following scenario:

A learner is sitting at the computer keyboard and the screen is displaying a menu of situational dialogues which he can choose to have presented on the videodisc unit. The learner chooses, say, a dialogue in French showing a guest registering at an hotel. The dialogue is acted out by native French speakers in a real French hotel. The dialogue may be presented with subtitles, in French or in translation, according to the learner's wishes. Sections of the dialogue may be reviewed at the press of a key. After the dialogue has been presented and the learner has reviewed it to his own satisfaction the computer then assesses his comprehension of the material in a series of questions, spoken or written, which relate to the new vocabulary and structures. Depending on the learner's responses, which are typed at the computer keyboard, sections of the dialogue can be presented again and again until the computer is satisfied that the learner has fully understood the material.

This may be a vision of the future, but technology has a habit of creeping up on us unexpectedly. Language teachers must react swiftly to the challenge of the new technology. It is up to them to write the new material and if they are unprepared there is sure to be someone else who will write it for them, maybe with disastrous results.

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PROVIDING EFFECTIVE AND AFFORDABLE COMPUTER-BASED EDUCATION

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ABSTRACT

Cost effective computer-based education (CBE) requires more than just inexpensive hardware. In the attempt to provide economical CBE, one valuable yet often overlooked asset are the users who must interface easily and effectively with the terminal and system. Determining the specifications of the system so that naive users such as students, authors, instructors, administrators, and researchers can efficiently accomplish their goals is an important task, one that determines the degree of usage and ultimately the cost effectiveness. This paper will examine some of the specifications determined as a result of twenty years experience with various users of the PLATO[®] system. The present day costs will be presented as well as estimated costs of providing equivalent functions using the latest technology.

The PLATO[®] system is a development of the University of Illinois.
PLATO[®] is the service mark of Control Data Corporation.

Providing Effective and Affordable Computer-based Education

INTRODUCTION

New technology has brought to the market place an assortment of computer terminals which are frequently advertised as an economical solution to the education problem. The task of educational administrators is to choose which computer terminal will best serve their needs and yet fall within the economic capability of their institution. It is the intent of this paper to offer some guidelines and considerations for analyzing the performance and cost of today's offerings.

The first task in considering a computer-based education (CBE) project is to define what is meant by effective use. It is usually better not to implement any approach until the project goals are clearly established. Since this medium of instruction is relatively new, the relationship between the system specifications and the desired goals is not always clear. Thus, the determination of specifications is not an easy task. When stating the specifications, care should be taken to avoid extreme positions. At one end of the spectrum, specifications could be so narrow or restrictive that they would allow no capacity for variance should the specifications fall short of reaching the set goals. For example, a display specification of "alphanumerics only" could limit the type of materials presented to those of the drill and practice type. Another example of a restrictive system specification would be the selection of a terminal solely on the basis of its performance in the student mode, and then later decide to create your own lesson material. At the other extreme is the position of having wide open specifications for fear of precluding even the most remote possible need of the users. This approach is likely to produce a prohibitively expensive system.

At the University of Illinois a flexible approach was taken to allow adaptation to the needs of the users as their needs developed and changed. In this approach where the system was developed in a user environment, an important system specification permitted the users to communicate their needs to the hardware and software staff. The specifications and the goals of the initial system were then modified as indicated by the users' experience and needs. This evolutionary system development produced the set of specifications for the author mode, instructor mode, and the student mode. As the goals and specifications were determined, the system was expanded in size.[1]

One should not conclude that the PLATO[®] system specifications are the proper ones for all types of users. However, these specifications do provide for the needs of a large variety of users and serve as an example for large system cost analysis. The cost for building and operating such a system in a variety of configurations has been established, and the expected cost for implementing these same system specifications with new technology can be estimated.

This paper will first examine some of the user determined objectives and give illustrative examples. Next, to provide an idea of the economics of large systems, the cost of operating the University of Illinois PLATO system will be discussed. Finally, the cost of implementing these same specifications using new technology will be considered. The costs of two types of systems will be presented. One system consists of a widely distributed network made up of terminal clusters. The other type of system is a large central system where all of the processing is done in the central computer. The central computer system has important implications for two way cable television.

AUTHOR MODE SPECIFICATIONS

Among the important provisions for authors is the capability to create

displays for the courseware with both ease and speed. To help with this function the PLATO system has a display editor. Lines, circles, and other geometric forms as well as text can be generated by the author who by touching the display screen with a finger indicates to the computer the important locations on the screen. Instructions on the use of this special author mode appear as prompting on the display as the author works. An example of a display being generated is shown in Figure 1a. The computer then takes the display specifications and creates the code necessary to generate the display. The resulting code for the preceding example is shown in Figure 1b. The author can also create or edit code in text form. The command structure is very natural; for example, command "circle" for a circle, etc., thus allowing the naive users to easily use the language.[2] In many cases, specially designed characters are needed. Again, an easy technique which would allow naive authors to create such characters was necessary. An example of character design is shown in Figure 2.

Another important function is the collection and compilation of student interaction data to determine the effectiveness of materials and where changes should be made in the instructional design. The student data which are gathered are presented in a variety of forms which are useful to the author. Examples of data presentation are shown in Figure 3.

Once a lesson or portion of a lesson is written, it can be compiled within a few seconds for testing in the student mode. The provision for instant error analysis as well as the ability to quickly run, test, and correct or modify partially completed programs is a great help to authors in producing courseware. Although these capabilities have made it possible for authors to produce and utilize excellent materials, having these features does not guarantee that all materials produced on the system will be effective. Good instructional design is as important as good system authoring capabilities.

INSTRUCTOR MODE SPECIFICATIONS

The majority of instructors who are using courseware are not experts in the area of computer programming. Thus, they must be provided with easily understood and useable functions which allow them to register students into their classes, choose and organize the lessons that make up their curriculum, and monitor student progress and achievement. Figure 4 provides examples of displays used by the instructor to carry out these procedures.

STUDENT MODE SPECIFICATIONS

For students a humane interface with the terminal is of utmost importance. To teach a variety of subjects effectively to different types of students, a display should meet certain specifications. The terminal must have graphic capability and present a clear display of sufficient resolution to sustain the graphics and alphanumerics of the courseware. Upper and lower case letters along with superscripts and subscripts are necessary if the textual presentation is to conform to that in normal usage. Finger-touch input has been found to be of great value for making selections on the screen and can greatly reduce the need for typing skills.[3] One of the most important functions, however is the ability of the computer to process students' responses in a conceptual manner rather than merely comparing them against a stored list of responses. This feature allows students to respond in a more creative and individualistic manner. Several examples of response judging are illustrated in Figure 5. Many more examples are available in previous publications.[4,5,6,7]

Audio and slide presentation capability of the terminal have been considered important factors in approximately 20% of the courseware.



```

- BLOCK 1-g - restore          SPACE = 297
1  s
2  draw  1920;1120;1100;1000;1020;
3  atm  000
4  circle 51,252,162
5  atm  240,280
6  circle 54
7  atm  2
8  rotate 78
9  at  2047
10 write  this is a wheelchair!

```

"e" indicates the center of a circle or reircle. you are asked to move the cursor to the edge.

(a)

(b)

Figure 1: The author creates a display graphically on the screen (a) and then the computer generates the code representing the display (b).

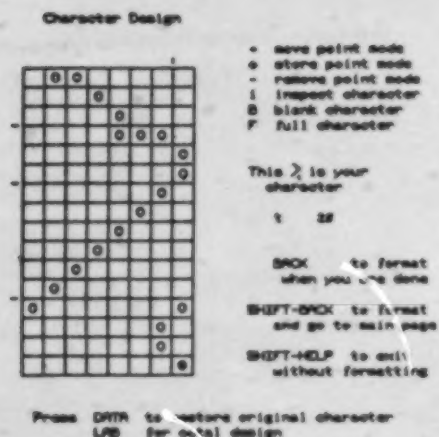


Figure 2: The author can construct special characters on the large grid. As the character is produced, it is shown in its proper size on the right side of the display.

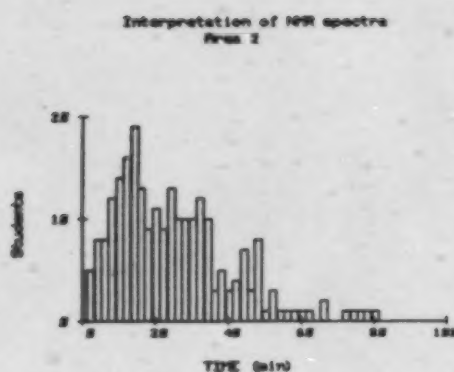
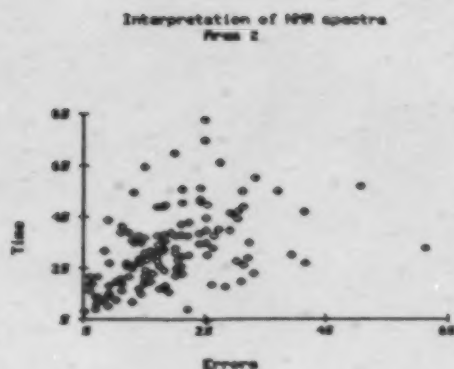


Figure 3: Accumulated student performance can be displayed in a variety of ways. This data has been collected by the computer from students working in an organic chemistry course written by Professor Stan Smith of the University of Illinois.

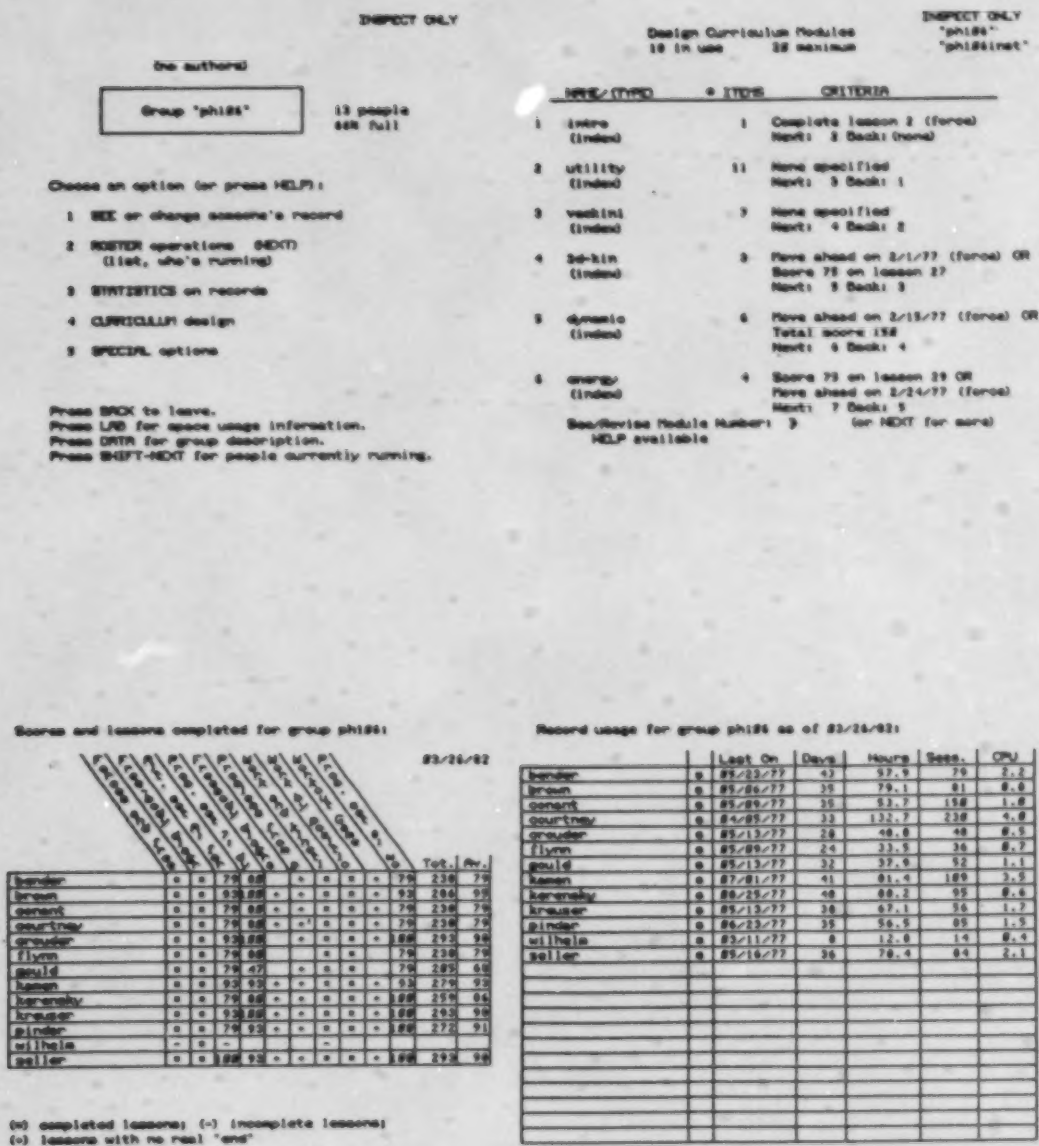


Figure 4: This instructor can use the system to help design curriculum modules, and then have the computer automatically monitor and display the students' performance on these materials.

If the acceleration is constant, the average velocity $\bar{v}$ can be written as a simple function of the initial velocity v_i and the final velocity v_f . Write an expression involving v_i and v_f .

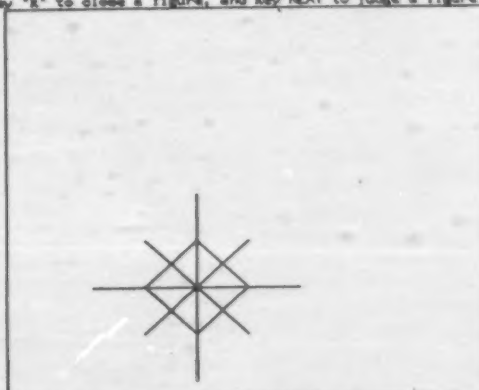
$\bar{v} = \frac{1}{2}(v_i + v_f)$ ok

Fine. A simpler form is $(v_i + v_f)/2$.

Press BACK to return to index.

(a)

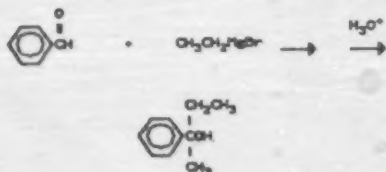
Draw a quadrilateral with only two lines of symmetry. Use arrow keys to move points around. Key "m" to mark a vertex key "h" to close a figure, and key NEXT to judge a figure.



No, your figure has four lines of symmetry. Try again.

(b)

Indicate the structure of the organic product of this reaction



This is a Grignard reaction

h no

(c)

male parent:
1 ok



female parent:
2



If you want to use any of these offspring, you must save them now. What do you want to do?

(d)

Figure 5: Flexible processing of the students' responses is important in CBE. Illustrated here are the computer's responses to algebraic input (a); geometric input (b); chemical input (c); genetic biology (d).

It is important for students to be able to obtain information concerning their performance and progress. Figure 6 illustrates one type of data provided to the students in a physics class which allows them to compare their performance relative to that of other students in the class.

It has proven valuable for the student, instructor and author to be able to communicate by sending notes or real-time typed messages. In addition, the ability to display the entire screen of another user, including its graphics, allows experts to assist other users located at remote sites. This feature also provides common displays for multiple-player games.

PRESENT COSTS

While subjective types of measurements are likely to influence the determination of CBE's effectiveness, the costs involved in the delivery of CBE are more visible and measurable. Consequently, cost frequently becomes the deciding factor in choosing a terminal or system.

Costs can also be misleading depending on how they are calculated. Are costs the net cash outflow? Are grants that support personnel who are only working on related projects used in reducing the costs of the service? Even the amount of terminal usage can be difficult to estimate.

To illustrate these points, consider the cost of using PLATO at the University of Illinois. Of the 1200 terminals connected to its system, approximately 500 terminals are in use at the University. The net cash flow is approximately zero. Patent royalty income is approximately equal to the Computer-based Education Research Laboratory's (CERL) University budget, and grants along with outside service fees cover the remaining expenditures. In addition, grants for PLATO related research in other departments of the University pay a portion of some faculty time. One could conclude from this that using PLATO generates a profit. However, since not every institution having a CBE system would have these unusual sources of income, a proper calculation of PLATO costs should be independent of how the expenditures are recovered. We can estimate the cost in the following way. The total budget at CERL is approximately 3 million dollars per year. This budget covers research and development in CBE as well as computer costs, maintenance charges for the computer and terminals, and all managerial and operating personnel costs. It does not include the cost of the terminals or long distance telephone lines. We estimate that of the \$3 million total, approximately 25% or \$750 thousand supports research and development, with the remainder supporting the existing computer services. Thus, the present service costs for supporting 1200 terminals is about \$2.25 million or \$1900.00 a year per terminal. Because some of the terminals used for internal research do not contribute their share of income, we charge regular users \$3000.00 per year for each terminal connection independent of the amount it is used. How does this annual cost translate to the cost per terminal hour? It is necessary to estimate the number of hours per year the terminal will be used. Our PLATO system is available for use about 8000 hours per year. A typical use of eight hours per day for 250 days would yield 2000 hours per year. The PLATO system keeps a log which provides us with data concerning the amount of use. A measurement of terminal access time indicates that the 1200 terminals consume approximately 1.5 million hours of use per year. Some terminals are used a great deal of the time while others are used very little. Our data indicates that over 900 of the connected terminals use the system each day with the peak simultaneous number of users being about 650 terminals. Using these numbers, the present PLATO costs for a variety of conditions can be calculated. Figure 7 is a table showing the results of these calculations.

Several interesting things can be seen from these calculations. First, the investment per terminal in the central computer service is five times the

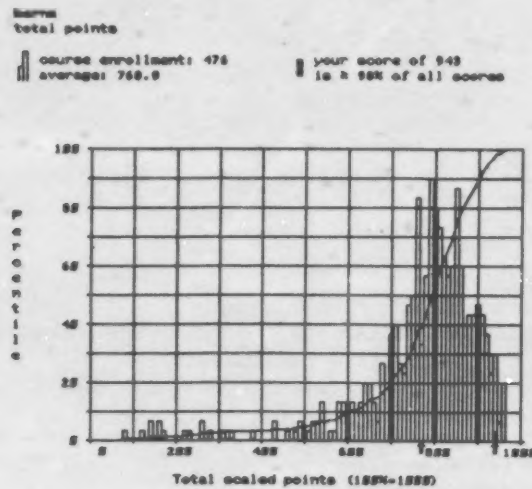


Figure 6: This is an example of student data presentation which allows each student to see how his record compares with his classmates.

Configuration	Service Fee Cost/Hour	Terminal Cost/Hour	Communication Cost/Hour	Total Cost/Hour
Local Terminal				
4000 hours	\$0.75	\$0.18		\$0.93
2000 hours	\$1.50	\$0.35		\$1.85
1000 hours	\$3.00	\$0.70		\$3.70
Single Remote Terminal (100 Miles)				
4000 hours	\$0.75	\$0.18	\$0.30	\$1.23
2000 hours	\$1.50	\$0.35	\$0.60	\$2.45
1000 hours	\$3.00	\$0.70	\$1.20	\$4.90
Group of 16 Remote Terminals (100 Miles)				
4000 hours	\$0.75	\$0.18	\$0.05	\$0.98
2000 hours	\$1.50	\$0.35	\$0.10	\$1.95
1000 hours	\$3.00	\$0.70	\$0.20	\$3.90
Group of 16 Remote Terminals (1000 Miles)				
4000 hours	\$0.75	\$0.18	\$0.50	\$1.43
2000 hours	\$1.50	\$0.35	\$1.00	\$2.85
1000 hours	\$3.00	\$0.70	\$2.00	\$5.70

Figure 7: Shown in this table are the present costs of PLATO service at the University of Illinois.

investment in the terminal itself. This is not unexpected since our computer is much older technology than the technology in our terminals. Second, the total cost of the present PLATO services is already reasonable under almost all conditions. For example, a local terminal in use 14 hours a day, 300 days a year, will cost approximately \$0.93 per hour. Even a remote terminal located in a group of 16 at a distance of 1000 miles and used for 2000 hours per year will cost only \$2.85 per hour. For CBE development, these costs are more than reasonable when compared to the human cost of a development program.

FUTURE COSTS

Although these costs are acceptable for CBE development, how can they be reduced in the future for large scale implementation? Since improved terminal performance is still an important priority, one might expect that new technology will be used to upgrade performance instead of lowering terminal costs. However, the other service costs can probably be reduced substantially. The existing service costs can be divided into two parts, equipment and people. New central computer costs are already about 10% of the present CERL computer costs. Part of the saving comes in higher calculational speed of the computer and part in reduced total cost for a computer. In our service costs about \$1.2 million per year is for the equipment, and \$1 million per year is for personnel. If the terminal maintenance is excluded, the same number of people could probably operate the service for a 16,000 terminal system.

It is interesting to speculate on the cost of a large central system capable of simultaneously supporting 8,000 of the 16,000 users connected via two way cable TV channel. Scaling the computer cost indicates that 8,000 simultaneous users would require a computer costing about \$1.92 million per year. Along with the 1 million dollars per year for personnel, the total of \$2.92 million dollars would have to be shared among the 16,000 connected users. This would cost each user approximately \$15.20 per month for the service. In addition they would have to buy and maintain their own terminal. This monthly service charge necessary to support a large integrated system seems to be low enough to survive in the home and school markets.

What can be done for the users who are remote from the central computer? When all the terminals are not attached to a single communication channel such as cable TV, communication costs can be expensive and the service unreliable. If a terminal is isolated geographically, there is not much choice but to either operate as a stand alone terminal or pay the communication cost back to the central computer system. When there is a group of terminals in a community, up to 16 terminals can simultaneously share a single telephone line, thus reducing the communication costs considerably.

For those users who may have large groups of terminals in quantities much greater than 16 but less than the several hundred necessary to support a small central system, another approach is possible. A minicomputer can be used to manage the loading of parts of the computer program into the terminals and then use the computer power in the terminal to execute the program. A single telephone line then can connect the entire cluster of terminals to the central computer for inter-cluster communications and the gathering of related data on lesson or system performance across the entire network. In this manner the communication cost can be reduced by as much as a factor of 8, and when the communication channel fails, many of the terminal uses can continue without interruption.

CONCLUSIONS

The most difficult task in CBE is to provide a system capability that will

satisfy the needs of a variety of users and encourage the production and use of effective courseware and other application packages. Equipment costs based on present technology are already reasonable when compared to the human costs in a CBE development project. Therefore, care should be taken to provide terminals and system performance which will minimize the human time necessary to integrate CBE into the educational system.

Future terminal and computer costs should be sufficiently low to allow large scale implementation. It will then be even more important that many useful application packages be highly developed and available so that effective use can be made by all types of system users. When this is accomplished, we can look forward to not only saving costs on human labor but also extending the capability of many of our scarce human resources.

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COMPUTER-ASSISTED INSTRUCTION IN TEACHER TRAINING IN THE RSA

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ABSTRACT

As a result of rapid technological progress, the computer has been developed and it will influence various aspects of educational field. No training institute for teachers can afford to allow that still another generation of teachers be trained without a basic knowledge of computer literacy. The aims, goals and objectives of Computer Aided Instruction (CAI) are clearly stated in this paper. In accordance with this the didactical principles which underly CAI should be applied. Different modes of CAI can be applied to heighten the efficiency of the teaching and learning process in the classroom. The different functions which CAI can fulfil are also stated. A model for teacher training in CAI is recommended and is aimed at the following: level of knowledge, level of ability and the level of disposition of the students' total teachers training programme.

COMPUTER-ASSISTED INSTRUCTION IN TEACHER TRAINING IN THE RSA

1.0 INTRODUCTION

A wide variety of reasons could probably be advanced as to why new developments in the field of micro-electronics are of cardinal interest for the teaching profession on its way to the year 2 000. It is already established practice that with systems such as CEEFAX, PRESTEL and VIEWDATA telecommunication takes place via the television screen. Very soon interactive instruction via the television screen will also be possible. In America they have also succeeded in perfecting the video disc, which has a large memorising capacity, seeing that one of these discs is capable of storing 108 000 television image frames. Both the SABC and the Post Office are doing research on the implementation of micro-electronics in various systems.

One of the most important developments in this field is probably the mini-computer. Smith (16 - 34) says the following: "More recently, computers have been made which are even smaller than mini computers. It is now possible to photograph a complex electric circuit and etch it in reduced size on to a silicon chip about 3 mm square. These chips are the basis of the micro computer, with which limited facilities can be provided at reasonable cost".

The internationally known scientist David Potter predicts in the light of this that "... the classroom computer will soon become an indispensable aid in the teaching process, and will have children of the 80's treat computers with the same familiarity with which they regard TV and hi-fi equipment" (Computing SA, p. 1). Governments and policy-makers in the industrial world have long since determined the range of the micro-electronic revolution for the coming twenty years. The question which now arises is how we have to train the rising young generation in the skills and techniques which they will need for effective professional functioning in the future.

The most important insight which has to be kept in mind here is not the replacement of teachers by means of computer-assisted learning, but the new generation will definitely have to be trained in the use of computers in the various school subjects. This is especially important for those school subjects which lean on computer-work, such as Mathematics, Physical Science, Biology, Accountancy and Statistics.

Seen in this way, no training institution for teachers can any longer dare to let a generation of teachers be trained without equipping them with a basic computer literacy. Computer literacy appears on three levels, viz.

- a. First level : Sensitizing. The student has to be made aware of the value of the computer for society and of the effects that it might have in education and training (Seidel, 15 - 482).
- b. Second level : Knowledge. The student has to have knowledge of the application of the computer in various subject fields, such as remedial content, language skills, laboratory simulations. He also has to know a basic computer language.

- c. Third level : Programming skills. Students should also be given the opportunity to write programmes. Instructions should also be developed by them and can then be adapted after evaluation.

This way of thinking is supported by von Solms (17 - 7) when he says that "Any first or introductory course in programming has to include the full range of programming, and should not only involve the acquisition of a specific computer language. Students have to be initiated into a specific algorithmic intellectual pattern which should form the basis of their further careers as programmers". From the very beginning, however, there should be a distinction between those students who are taking computer science as an academic and professional science and those students - the large majority - who only have to have knowledge of the computer to support their studies in education-directed fields, to enable them to apply the computer effectively in the teaching-learning situation as an aid.

2.0 What is computer-assisted instruction (CAI)?

In recent literature dealing with this subject, the following abbreviations are often found:

- CMI - for "Computer Managed Instruction"
CAI - for "Computer Assisted Instruction" such as PLATO ("Programmed Logic for Automatic Teaching Operation")
TICCIT - for "Time-shared Interactive Computer Controlled Information Television"
CAL - for "Computer Aided Learning" - Perry and Keyser (12 - 172).

It can also be stated that computer-assisted instruction (CAI) is mainly used for more effective teaching and that computer-managed instruction (CMI) more often stresses the elimination of routine (Hattingh, 9 - 188). For the purposes of this paper the term CAI will be used. It is therefore implied that this is teaching of students which is then supported by the computer. Du Plessis (5 - 28) prefers to call this computer-supported instruction.

Perry and Keyser (12 - 174) summarise the meaning of computer-assisted instruction well when they maintain that "Computer instruction is a medium designed to promote efficiency in instruction".

The computer may be used in the following ways and at the following levels in the instructional situation:

- As a - drill and practice system
- instructional system
- investigative system
- dialogue system
- simulator
- computer game system (Conradie, 4 - 95).

The four functions idiosyncratic to computer-controlled instruction on the other hand, are:

- marking of tests (to generate and analyse test items);
- prescription for the student (answer analyses);
- report keeping (storing of data in memory);
- report making (typed report on progress).

In the subsequent section, attention will be given to the aims striven for with CAI.

3.0 Objectives with computer-assisted instruction

The ideal instruction-learning situation would probably be one in which the teacher can offer instruction and guidance to each individual student. In the ordinary classroom situation it is fairly difficult to optimise such an interactive action seeing that the teacher has to keep account of a large number of variables.

The computer can make a large contribution towards making possible this ideal 1:1 relationship. Educationists, however, should always keep in mind that "... there is nothing more impersonal than computers, and nothing more personal, than taking care of children" (Computing SA, 1981, p. 20).

With these in mind, the following objectives may be striven for with CAI:

- 3.1 Properly prepared programmes allow constant interaction with the medium, which supports the principle of student participation.
- 3.2 Interaction takes place on a continuing basis with the lecturer as well as with the computer.
- 3.3 As many of the senses as possible (hearing, sight, touch, etc.) are involved in the learning activities of the student.
- 3.4 CAI, as an instructional medium, has been designed to make teaching more effective.
- 3.5 CAI makes provision for the involvement of the sensory as well as the motor skills of the student.
- 3.6 Individualising of instruction, through which immediate feedback may be offered to each student, comes into its own.
- 3.7 The modular construction of learning content ensures that small amounts of information may be assimilated properly.
- 3.8 Skills which may be defined objectively may be practised by the student. The easier skills are usually followed by more complex skills.
- 3.9 CAI is based on the model of learning by mastery, where a particular set of information has to be mastered before progress can be made to the next one. Sometimes an additional or remedial module may be completed before progress is made to the one next in line.

- 3.10 CAI is both prescriptive and diagnostic in nature, seeing that every student has to be tested thoroughly and any gaps in his armoury of learning be identified.
- 3.11 CAI is tuned into a multi-sensorial approach because the learners respond by pressing the keys on a keyboard, or by touching the video screen which represents the learning content such as graphs or imitations.
- 3.12 CAI makes use of a variety of instructional approaches or methods, such as practice, remedial aid, diagnostic methods, learning by mastery, reproduction of knowledge, etc.

4.0 Didactic principles underlying CAI

In any situation involving teaching and learning all didactic and educational principles will be important of necessity. CAI is no exception in this regard, but there are still a few principles which support CAI in particular. We would like to refer to a few of these:

4.1 Individualization

This principle emanates from the concept that the intellect, skills, attitudes and tempo of learning are unique. When traditional instruction is given to students or pupils, they often have to accept the tempo of learning of the group. Learning problems developing in the individual student then cannot be identified all that easily. It is only when a test is written and the student's achievement indicates that he has not mastered certain facets of the learning content that remedial work will be done. With the advent of the computer the possibilities to individualize instruction have increased greatly.

Serfontein (14 - 14) says of this that "... the optimal implementation of the computer in the instructional situation will imply maximum individualization". This means that with the help of the computer individual tuition can be given to each student. Each student's learning needs are taken into account and he works at his own tempo. Individualization therefore takes place with regard to the student's personality, interest and intellectual capacity.

These individualizing possibilities are at present realised in CAI by means of the choice of a modus; the choice of learning content and the choice of a standard that has to be set.

4.2 Mastery learning

Bloom, as quoted by Block (1 - 15) defines mastery learning in the following terms: "It begins with the assumption that most students can attain a high level of learning capability if instruction is approached systematically, if students are helped where and when they have learning difficulties, if they are given sufficient time to achieve mastery and if there is some clear criterion of what constitutes mastery".

Bloom's strategy for the attainment of mastery learning involves the following components:

- a. The lecturer determines the criterion for the mastery of the course.
- b. Objectives which have to be attained in order to achieve the standard of mastery learning.
- c. The course or the learning content should now be divided into course content modules which follow each other progressively.
- d. Short, ungraded, formative or diagnostic tests are compiled for each learning content module - these have to be completed inter-modularly.
- e. Alternative learning content modules which can be either remedial or supplementary to the original learning content module should be worked in.
- f. A synoptic or summative test which is written post-modularly determines what the learning gain of the student has been (Calitz, 2 - 6, 7).

Keller's so-called "Personalized system of Instruction" (PSI) is aimed at changing the role of the lecturer as the disseminator of information to the role of manager of instructional-learning activities. According to this strategy a student, should he be unable to attain the criterion expected of him, would be expected, after a formative test, to work through the contents of the basic learning content modules before he may move on to the next module.

In the ordinary classroom form of organization the application of the mastery learning principle is seldom possible because syllabi have to be completed within a set period of time. Because of the opportunities which CAI offers for individualizing this principle may be applied effectively.

4.3 Competency-based training

A competent, effective teacher is a person who has mastered certain specific teaching skills and who may, through the implementation of those skills influence the learning achievements of pupils in a positive fashion. Peter (13 - 3) says of this that "... a teacher's competency ... must be determined by the effects of the teacher's performance on children's learning".

Competence of a teacher can be regarded as important from three different viewpoints:

- a. orientation as regards objectives;
- b. evaluation and assumption of responsibility; and
- c. individualization.

Brinkerhoff (13 - 22) ties in with this when he says that "Competency assessment is a procedure engaged into answer such questions as:

- * how well did students learn what we expected them to learn?
- * how did they progress through the programme?
- * what did they achieve?
- * what in the programme worked? What didn't?
- * what can students do when they leave the programme?"

With the aid of CAI a wide range of teaching skills can be practised at the level of the cognitive, psychomotor, affective (or combinations of these), so that the student of education might later incorporate these into his teaching style.

4.4 Answer analysis

CAI attempts to ensure the principle of active participation by the learner and to unfold the heuristic or self-discovering strategy. Active participation is possible on the basis on the questions and assignments which the computer sets the student; or on the basis of requests, questions or assignments which a student directs at the computer at his own initiative (Serfontein, 14 - 15).

Answer analysis will investigate, analyse and interpret the responses of the pupils. In CAI answer analysis should be able to distinguish the most probable answers or responses of a student because this then determines the further course of the interaction.

5.0 Modi of CAI

The computer may be applied in the following ways or modi to gain optimum efficiency for instructional-learning activities. "These modi which may be described as the ways of CAI in themselves offer possibilities for individualizing, but can not yet be regarded as the final answer" (Serfontein, 14 - 11). A few of these modi will be looked at briefly.

5.1 Drill and practice

The principles here is that after certain learning contents have been opened up to students as concepts, the computer should be used as guide, controller or monitor in order to drill and practise these concepts. The purpose with this is to assimilate insights by means of constant practice until they attain the required level of skill (Serfontein, 14 - 11). (Also of Hattingh, 8 - 25). According to Du Plessis (5 - 34) CAI can, through the supply of drill exercises, give necessary reinforcement.

5.2 Tutorial

This modus of CAI is more complex because new learning content is offered by the computer and a higher degree of insightful skill will be expected of the students (Hattingh, 8 and Serfontein, 14 - 12). Questions set serve the purpose of determining whether students reveal insight and comprehension. Wiechers (18 - 8) regards the modi of drill and practice and of tutorial as simulations or imitations of conventional teaching methods.

5.3 Problem solving

Specific problems are set by the lecturer with the aid of the computer, and the students then have to do certain assignments or solve certain problems. The student has to be able to communicate with the computer by means of computer language in order to commit the necessary information and steps for problem-solving to the computer. According to Hattingh (78 - 26) the pupil then uses problem-oriented language which gives him control over the system. Conradie (4 - 98) refers to the problem-solving technique as an inquiry system. According to him the learner is placed in a structured situation in which he has to ask questions which will ultimately lead to the solution of the problem. Data on the learner's efforts are stored and evaluated and hints on problem-solving are supplied.

5.4 Free dialogue

Through this modus the student himself has a free and natural dialogue with the computer by setting questions, making suggestions, requesting information or offering solutions (Serfontein, 14 - 13). The modus is less formally structured and sometimes, on the basis of an analysis and interpretation of the student's suggestions, inquiries and solutions, certain information is made available to the student. On the other hand the computer can take the initiative and pose questions to the student, thus having a dialogue with the student in order to realize specific aims or objectives (Conradie, 4 - 98).

5.5 Simulation and play

The computer can simulate real situations for the learner. Simulation rests on the principle of analogy (Conradie, 4 - 98). This imitation of the situation drawn from reality may be influenced, controlled and checked by a number of parameters (Serfontein, 14 - 13). By manipulating the parameters various conditions can be created in the situation.

Simulation can also assume the shape of play. Hattingh (8 - 28) in this respect mentions a game in business management which is imitated, and in which students have to make decisions with regard to capital spending, manpower implementation and the use of stock. Laboratory experiments can also be simulated. Simulation packages are also used in engineering, aviation and mechanical engineering. According to Hattingh (9 - 192) the advantage of a simulation programme is the fact that the student can work with a simpler model than the one he will encounter in real life, he is also more quickly to see the results of his decisions and actions, he will be certain that wrong decisions and actions will not have serious consequences and will be able to be rectified more easily.

6.0 Functions that CAI may fulfil in teaching

The following functions might be fulfilled in education by CAI:

- 6.1 The computer may be used for regular revision, drill and practice of insights (automatically), to evaluate results and to offer a report without the need for additional actions by the lecturer.

- 6.2 The computer can keep a record of each student's efforts, his progress as well as his failures. In this way the teacher is able more quickly to arrive at an estimate of the pupil's abilities.
 - 6.3 Objective evaluation would be hard to find, because in contrast with the ordinary teaching situation all pupils are treated equally in examination (Conradie, 4 - 45).
 - 6.4 Peripheral units, such as the cathode ray tube and plasma touch screen which can be switched into the computer can enrich the world of experience of the pupil.
 - 6.5 The teacher can individualize his teaching more successfully through the assimilation of a technological medium such as the computer.
 - 6.6 Administrative routine, such as the compilation of school reports, class lists, marks sheets and other work of this nature may be given to the computer.
 - 6.7 The problem of a teacher shortage and an unfavourable teacher : pupil ratio can be resolved through making better use of the available teachers with the involvement of the computer as an educational medium.
 - 6.8 When the term "computer-assisted instruction" is used in the narrower sense of interactive instruction with the computer (as opposed to computer-controlled instruction), the latter mainly has less expensive education as its purpose, while the former is mainly interested in more effective instruction (Hattingh, 9 - 200). There is also the possibility that a healthy balance between cost and effectiveness may be obtained, or even that effectiveness may ultimately bring about a reduction in costs.
- 7.0 The training of teachers with regard to CAI
- * It is clear that the successful implementation of the computer in the training of teachers will depend on the attitude of the student. Ellis (6 - 7) says the following: "Teachers who have to use a computer for some reason, such as student statistics, have the attitude that computers are so complicated that only programmers can use them".
 - * The computer can play an important role in the student's attitude towards a certain subject, but then only if it is exploited as an integral part of a well-planned curriculum.
 - * Not only should students be trained in the possibilities and the use of the computer, but even the practising teacher has to be made conscious of the potentialities of the computer. The teacher therefore has to be convinced of the fact that the computer is supportive of his already good teaching and that it can further improve it.

- * Ellis (6 - 8) also indicates that our children today are born into a society in which computer games and sources of information, such as ERIC, CAN/OLE, are available in libraries. In fact, they are given pocket computers for Christmas gifts and when they open their first bank account, this is already on a computerized system. With regard to the training of teachers, he says that: "How is education preparing for the future computer age? Educators must read the convincing signs and make significant changes to the teacher education programs. Computing must be included so that future teachers can provide the most effective teaching and be able to prepare students for the world they will enter. Educators, let us not turn our backs again."

8.0 A training model for teachers in CAI

In the same way that the teacher uses standard teaching media, such as the overhead projector, sound slide projector, 16 mm movie projector and textbooks to make his teaching more effective, he should also use the micro-computer in teaching his subject.

Students should thus be trained to have a basic knowledge of computers and especially micro-computers, and also knowledge of computer applications by means of the micro-computer. Trainers of education students will thus strive to accomplish CAI on three levels of the student's training, viz.

8.1 On the level of knowledge

Here the students has to have knowledge of computer language, apparatus and programming of the micro-computer in particular. The subject-didactic implementation of the micro-computer in the teaching of his subject should also be mastered. Computer printouts should be analysed and interpreted.

8.2 On the level of being able to

That is, specific skills have to be acquired and applied by the students, for example loading a pliable disc driving unit, opening of the computer, writing of a simple programme, emendations of an existing programme and printout of data as well as elementary maintenance actions.

8.3 On the level of being

This means that the attitude of the student towards CAI should be correct. He should not see the computer as a threat to his status or his abilities, but as an ally and an aid to individualize teaching. It is especially with reference to the gifted pupil and to remedial teaching that this is important.

8.4 Recommended curriculum for the training of teachers

The following learning content should be included in a curriculum for CAI:

8.4.1 Definition of concepts

What is a computer, computer-assisted instruction, computer-assisted learning, apparatus, programming, etc.

8.4.2 The computer

- * Elementary study of the basic components of a computer (apparatus) and programming. Factors determining the choice of a computer. The micro-computer.
- * Writing of elementary programmes. Programme packages available.
- * Applications of the computer.
- * The computer in the training-learning situation. Educational implications of computer-assisted training.
- * The functions of the computer, such as drill systems, simulation, answer analysis, etc.

8.4.3 Foundation for CAI

- * Importance, possibilities and limitations of CAI (critical evaluation).
- * Foundational viewpoints with regard to CAI.

8.4.4 Subject-didactical CAI

Various educational methods which may be followed with the help of the computer, as well as the opportunities for learning and experiences of learning which learners may gain with the help of CAI.

8.4.5 Evaluation

- Theoretical: a 1 hour theoretical paper.
- Practical: Each student has to be able to write a short, elementary programme in the field of his school subjects. This will only be realizable if the necessary apparatus (terminals, screens, etc.) can be provided.

8.4.6 Number of periods

A minimum of three periods per week, that is, one theory and two practical (Malan, 10 - 2).

All teachers should be made aware of the cardinal role which computers will play in the last two decades of this century in the lives of mankind. The need for computer literacy will, in the course of the next two decades, also become greater in the non-formal educational public, and they will look for ways and means to eliminate this.

9.0 Computers which may be used for the training of teachers

There are four types of computers which may be used by the trainers of teachers.

9.1 PLATO

The PLATO System ("Programmed Logic for Automated Teaching") has been developed by the Control Data Corporation of the USA in conjunction with the University of Illinois. This system functions through many terminals which have been linked with a large central computer. The student works his way through the teaching content by typing his responses or by touching the terminal or the sensitive screen. The PLATO System uses TUTOR language which is difficult. PLATO is important because it has available a wide range of courses in a variety of subjects.

"PLATO offers the most courses or courseware, about 3 000 hours for the equivalent of 55 school courses which meet five days a week for 45 minutes a semester" (Callison, 3 - 25).

Added to that PLATO has a very large information capacity because it is an "on-line" system where terminals link directly with the central computer. Teachers and students who want to use this system should have a thorough training in its use beforehand.

9.2 TICCIT

This CAI System ("Time Shared Interactive Computer - Controlled Information Television") uses mini-computers and adapted TV-receivers. This system is, unfortunately, not available in the RSA. The system was originally developed for undergraduate Maths and English courses (Du Plessis, 5 - 30).

"TICCIT, which uses a mini-computer, also provides terminal displays in color with all visual media including film, videotape and slides seen on the terminal screen rather than in other parts of the room as is the case with PLATO" (Callison, 3 - 26).

Both PLATO and TICCIT provide instructional data, analysis, diagnosis and are prescriptive as regards students' assignments and advice. The great difference between the two systems lies in the cost, information recall and visual presentation.

"PLATO can display textual materials and graphic designs in black and white with a 'touch' screen for students responses, TICCIT can display color graphics, slides, film, and videotape along with text and can be switched from one mode to another rapidly. It has a 'touch' screen capability as well" (Callison, 3 - 27).

9.3 The DIDACOM or CYBERCOM system

The correct name for this system is the "Cybercom Multimode Education Communication System" and it is based on the systems approach which has the basic viewpoint that teaching and learning incorporate a number of strategies and methods. The system has been designed by Dr Jack Zawels and is aimed at providing individual training to large groups of students simultaneously.

The DIDACOM System is a modular unit and comprises a maximum of 256 terminals. It consists of the following four basic components:

- a. The student's terminal with a full alphabet, figures and symbols to create 64 characters. This corresponds to a typewriter keyboard.
- b. A console that is controlled by the lecturer. This contains a monitor which shows the students' responses, as well as the percentage of students who respond, and it shows who is correct.
- c. A teleprinter which has been combined with a ribbon punch card. This enables the lecturer to obtain a computer printout of the students' efforts. Statistics for further use may be obtained in this way.
- d. A mini-computer which is housed in a separate cabinet next to the system. This system may then store the programmes as well as the responses of the students.

The advantages of this system for teacher training are the following:

- a. Direct feedback is available immediately to the student.
- b. At any stage in the course of the programme the lecturer can cut in on the student's efforts or mistakes.
- c. No knowledge of programming is necessary to run the system - programmes are written in ordinary language.
- d. Greater latitude is given to the students in working through teaching contents than is the case with other systems.
- e. Eight different groups can work in different modi all at the same time.
- f. Terminals can also be placed in study cubicles if the student should want to work through programmes individually.
- g. Books and other study material may also still be integrated in conjunction with the Didacom System (Lomax, 11 - 249 - 252).

9.4 The Micro-computer

Callison (3 - 25) says, with reference to the micro-computer, that "The microcomputer is the one everyone is talking about today. It is small, like a television set, and inexpensive. It has a small but impressive memory and is selling at the rate of about 300 000 a year, mostly for youngsters to play games on at home."

The development of the micro-computer in the field of educational technology has been compared with a second industrial revolution. Four basic similarities exist with the industrial revolution:

1. The extent and the range of the change. During the industrial revolution man had to adapt his muscles to handle machines. In the computer revolution he has to adapt his brain to keep pace with the new developments.
2. Changes have been rapid. Where the Industrial Revolution took 100 years to complete, the computer revolution will be completed in the course of 25 years.
3. Growth has been phenomenal and cannot be halted or reversed.
4. Only a small group of people were tuned into the monumental changes brought about by the revolution.

As a result of the development of micro-computers the time will come when people will have to include the following in their "repertoire" of abilities:

- a. The ability to have interaction with a computer as a user.
- b. Be able to interpret computer printouts.
- c. The ability to analyse a problem and to hand it over to a programmer.
- d. The ability to suggest alternatives for a specific programme in order to achieve particular objectives. "Computer literacy is thus aimed at giving everybody a better understanding - relative to that which exists at present - of what a computer is, how it works and what it is used for" (Fisher, 7 - 7).

The advantages of the uses of the micro-computer in the training of students are the following:

- * it is inexpensive;
- * it is portable;
- * it is totally under local control;
- * it is reliable;
- * it can handle high level languages and use editors which, for the purposes of CAI, compare favourably with larger computers;
- * some micro-computers can handle complex images with the inclusion of graphic representations, speech, sound and colour; and
- * it is not so sensitive to environmental factors as larger computers (Hattingh, 9 - 205).

The micro-computer also has disadvantages. The disadvantage of isolation is there - meaning the fact that programmes cannot be shared with other institutions. The exchange of standardized packages by means of magnetic tapes and pliable discs to some extent compensates for this. If teachers could also be trained for it, they can do their extensions or improvements

of programmes by means of standard systems and standard language, then these could be transmitted to other schools. It is of course possible to link these computers in a network system.

As a result of the low price and the capabilities of the micro-computer, Fisher (7 - 7) says that "Computers are with us now: in our homes, offices, factories, schools and shops. To name but a few applications: pocket calculators, pocket language translators, word processors in the modern office, video and computer games, electronic clocks, microprocessors in cars, washing machines and data banks for recipes".

10. Concluding remarks

- * Education students have to do a basic training course in CAI. The necessary funding, infrastructure and apparatus and programming for this purpose should be found. This training has to be concentrated on users of computers and on programmers.
- * Active research as to how the computer can be used to eliminate knowledge in teachers in the RSA should be undertaken. This research should also be aimed at improving the relationship between student and teacher.
- * Programmes based on well-founded didactic theory should be developed. These programmes should take full account of the initial situation of learners.
- * Teachers may co-operate actively in the writing of suitable programme packages for specific school subjects.
- * A central body which can operate as an information-dissemination institution should be instituted, so that education packages can be centralized, documented and evaluated.
- * A remedial instructional aid service for pupils (especially in subjects such as Maths and Physical Science) should be instituted.

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SIMULATION OF DYNAMIC SYSTEMS BY MEANS OF MINI- AND MICROCOMPUTERS

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ABSTRACT

Two aspects of computer-aided education are potentially relevant to Engineering: the use of computers for drill-type lessons and as simulators of real world situations. Due to the emphasis placed on synthesis in Engineering, the simulation usage of computers is dominant in this discipline. In Electrical and Electronic Engineering, simulation activities include both the usage of simulations to optimise a design by scanning a wide range of state variables as well as techniques to implement a realistic simulation.

SIMULATION OF DYNAMIC SYSTEMS BY MEANS OF MINI- AND MICROCOMPUTERS

This paper will try to place simulations in perspective to other usages of computers in the educational environment. To do this we will have to investigate three topics:

- A. The activities in the three dominant fields, i.e.
 - (i) Standard CAI for existing material
 - (ii) Computer Science where the computer is the subject
 - (iii) Simulations where computing is the tool
- B. Characteristics of these three fields when computerised.
- C. The system requirements and practical solutions for simulations.

A. Activities in the three dominant fields

- (i) The main characteristic of Computer Aided Instruction is that it is trying to replace or aid a teacher to present an existing curriculum. Use is made of the computers excellent repetitive and memory characteristics. The user and teacher does not need an intimate knowledge of computers. Programming is therefor also usually done with the aid of a coursework designing application - software - package. Although this activity is nearly as old as the computer industry itself, the different philosophies are not yet standardised or generally accepted due to the controversy in connection with the duties of a teacher in such a system.
- (ii) In Computer Science where the computer is the subject, the activities are that of supporting any computer usage architectural in both hardware and software. It should be remembered that in this field the computer is also used in aiding the educator, therefor CAE is also practised. The techniques and philosophies are fairly standardised and universally accepted. Intimate knowledge of the computer systems used is inherent in this field.
- (iii) Simulations where computing is used as a tool is often ignored when CAE is discussed. In reality it is the most widely practised CAE. All computer aided design activities, equation solving, dynamic system simulations, management decision games, operation research, war games etc. are examples of this field. Here the computer is intimately used for numeric calculations to obtain a quantitative result which is used by the student to understand his subject material. The teacher is in no way replaced. In fact, the

computer is used to obtain results that would have been time consuming and therefore detrimental to the education process, if it had to be obtained without a fast computing device. In this field the computers enables educational processes that would have been virtually impossible without it. Examples of this is sensitivity analysis of a big nonlinear system to varying parameters and debugging a new design for a computer system by simulating it before it is actually built. This activity in CAE is as old as the computer industry and probably the widest, universally accepted application of CAE.

B. Characteristics of these three fields when computerised

- (i) In standard CAI, the whole process that is implemented is a discrete process and the discrete nature of the computer handles it with no problem. The educational user of teacher is dissociated as far as possible from the computers hardware and software to make it user, friendly. A centralised group of computer experts is used to write the main support-software.
- (ii) The computer scientist has no problem to handle his CAE because both the teacher and student is familiar with the computer and manipulates it architectural. They in fact normally provides the experts for the software support of the CAI activity.
- (iii) The simulation field provides the biggest fundamental problem of the three when a computer is used. Most of phenomena that is handled, is basically continuous, while a discrete computer is used to represent them. This discretisation is an approximation and the teacher and student using them must realise that not the true behaviour, but an approximate behaviour is solved by means of the digital computer. Purely mechanical usage of the computer as a tool is therefore undesirable in simulations, while it is practical in standard CAI. In this field the user must be aware of the errors of numerical methods, effects of time discretisation and finite number representations, alternative numerical methods and so on. A reasonable to good understanding of the tool is therefore required for effective application of CAE in this field. Almost all failures in the application of computers in design and simulation can be attributed to a lack of understanding of the discrete nature of the computer and the inherent approximations. Solving a set of differential equations by means of a digital computer can exhibit wild oscillations while the true solution varies smoothly, because a not applicable integration method is used.

C. System requirements for simulations

To provide a tight feedback-loop around the educator and student, the following two requirements must be met for simulations to be effective in CAE.

- (i) The number-crunching capability of the computer must be fair to good to restrict the delay in information-flow from machine to man to an acceptable value. This can be achieved by utilising either a single fast computer or by partitioning the problem so that a number of slower computers, even microcomputers, can be used to do the simulation. The latter is quite common in hardware- simulations where for example one microcomputer is used to simulate the input-output system of a computer under test, another microcomputer or processor used to simulate the instruction set of the simulated system and a third microcomputer used to interact with the designer to provide the feedback and input interfacing needed for closed-loop CAE. In such a system the designer is rapidly provided with the necessary information on the behaviour of his design, enabling him to modify it and thus educating the designer to produce a more effective design. Special digital signal processing hardware like array-processors may also be needed.
- (ii) The man-machine interfacing requirement in simulations can be much more demanding than in standard CAI. Input-output mechanisms like joysticks for aeronautical simulations, analog-to-digital and digital-to-analog converters for hybrid simulations where part of the system is simulated and part is real, highly interactive graphic screens and digitisers to do geometric computer aided design, computer-automated laboratory instrumentation etc. is quite common in simulations and unknown in standard CAI. Many of this man-machine interfaces are becoming microprocessor based themselves and loosely coupled multiprocessor systems is the result.

Both the requirements of high computing speed and tight man-machine interfacing is therefore forcing the systems of the future into multiprocessor or multicomputer systems. This in turn requires more standardisation in interfacing, processes, software and communication protocol. With UNIX for 16-bit machines and CP/M for 8 bit machines, software portability and machine to machine communication is becoming easier and multicomputer simulations is becoming a practical proposition to meet the speed and man-machine interfacing requirements. Fortunately interfacing is also slowly becoming standardised due to the various IEEE bus-standards defined for word-serial, byte-serial and bit-serial communications.

CONCLUSIONS

The use of simulations is only effective in CAE if the user is aware of the approximations made in discretisation of the simulated system, and if the feedback-loop around the student is closed with a minimum time-lag and with user-friendly man-machine interfacing. Standardisation of interface busses and software operating systems make this task easier due to the power of a distributed multicomputer simulation system. Unlike with standard CAI, the simulation user needs a reasonable knowledge of his computer system to use it effectively.

SOUTH AFRICAN SECONDARY SCHOOL CURRICULA DEVELOPMENT PROGRAMME

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ABSTRACT

In response to the growing need for basic and secondary school level educational materials in South Africa, Control Data (Pty) Limited decided in 1980 to commence work on SASSC -- the South African Secondary School Curricula programme. The SASSC programme is a large-scale, multi-year effort to develop individualised, computer-based curricula matched to the requirements of the various matriculation examining bodies. Currently under development are PLATO-based curricula for standards 6-10 in Physical Science and Mathematics. This paper describes design characteristics of the SASSC materials and outlines the multiple-phased process used in their development.

INTRODUCTION

Need for Secondary Level Academic Courseware

There is a tremendous need in the Republic of South Africa for high-quality educational programmes at the secondary school level. This need is felt by individuals, by commercial and industrial interests, and by education and training institutions throughout the country.

For individuals the attainment of a secondary school matriculation certificate is an important but often illusive goal. Possession of a matriculation certificate opens doors for the pursuit of higher education and economic advancement. Failure to achieve matriculation may severely limit a person's opportunities.

Business and industry require large numbers of technically skilled workers and management personnel, but these skills are in short supply in the work force. To provide continued economic growth, companies must develop technical and managerial skills in their current employees. A major impediment to this effort has been a shortfall of basic and secondary academic skills.

The present educational system seems inadequate to meet the demands of a growing business economy or to assist all individuals in reaching their potential. This is evidenced by the high dropout rate throughout the school system and the severe shortage of qualified teachers.

New means must be sought to assist teachers and educational institutions, and other media must be used to supplement the formal classroom teaching system. Out of sheer necessity advantage must be taken of advances in instructional technology such as those provided by Computer-Based Education (CBE).

SASSC Development Programme

Because of the need for high-quality instructional materials at the secondary level and because of the potential benefits of its PLATO[®] computer-based education system, the Courseware Development Department of Control Data (Pty) Limited decided in 1980 to commence development of SASSC -- the South African Secondary School Curricula programme.

Control Data's SASSC development programme is a large-scale, on-going, multi-year effort to develop secondary school level computer-based curricula. The SASSC curricula are intended to assist students to complete successfully the National Senior Certificate (NSC), Joint Matriculation Board (JMB), or other Senior Certificate examinations.

[®] PLATO is a trademark of Control Data Corporation.

By providing high-quality computer-based curricula on selected matriculation subjects the SASSC programme will assist individuals in qualifying themselves for higher education and more rewarding employment. It will also assist commercial interests in efforts to upgrade their employees' job skills. Furthermore, by providing supplementary instruction, diagnostic testing, and record-keeping, it will assist teachers in education and training institutions in their basic mission.

The SASSC curricula are being developed through application of a systematic development process model designed especially for the preparation of individualised, computer-based instructional materials [1] [2]. The model involves a step-by-step approach through a sequence of six major phases of activity: Analysis, Design, Development, Formative Evaluation, Implementation, and Summative Evaluation. (See [1], [2], [3], [4], and [5] for further information about the model and examples of its use).

The purpose of this paper is to describe the nature of the SASSC curricula and outline the approach being followed by Control Data in design and development of SASSC.

CURRICULA DESIGN

Analysis of Target Population

The needs for secondary school level, computer-based curricula in South Africa are widespread and are experienced by individuals in several institutions. Figure 1 illustrates the range of institutions and the likely uses of SASSC materials to be made by each.

The following statement summarises the broad design applicability of the SASSC materials:

Every South African whose level of schooling is between standard 5 and standard 10 is a potential user of the SASSC curricula.

Selection of Subject Areas and Topics

Selection of subjects. After analysing the needs of industry and the schools, the SASSC project team determined that the subjects having highest priority for computer-based curricula are Physical Science, Mathematics, and English. This conclusion is supported by the facts that:

1. Technical training requires secondary level knowledge of Physical Science and Mathematics.
2. Teacher staff shortages, or lack of qualifications, or both are most severe in Physical Science and Mathematics.
3. English, though very important in the commercial environment, is not used well by many persons in the work force.

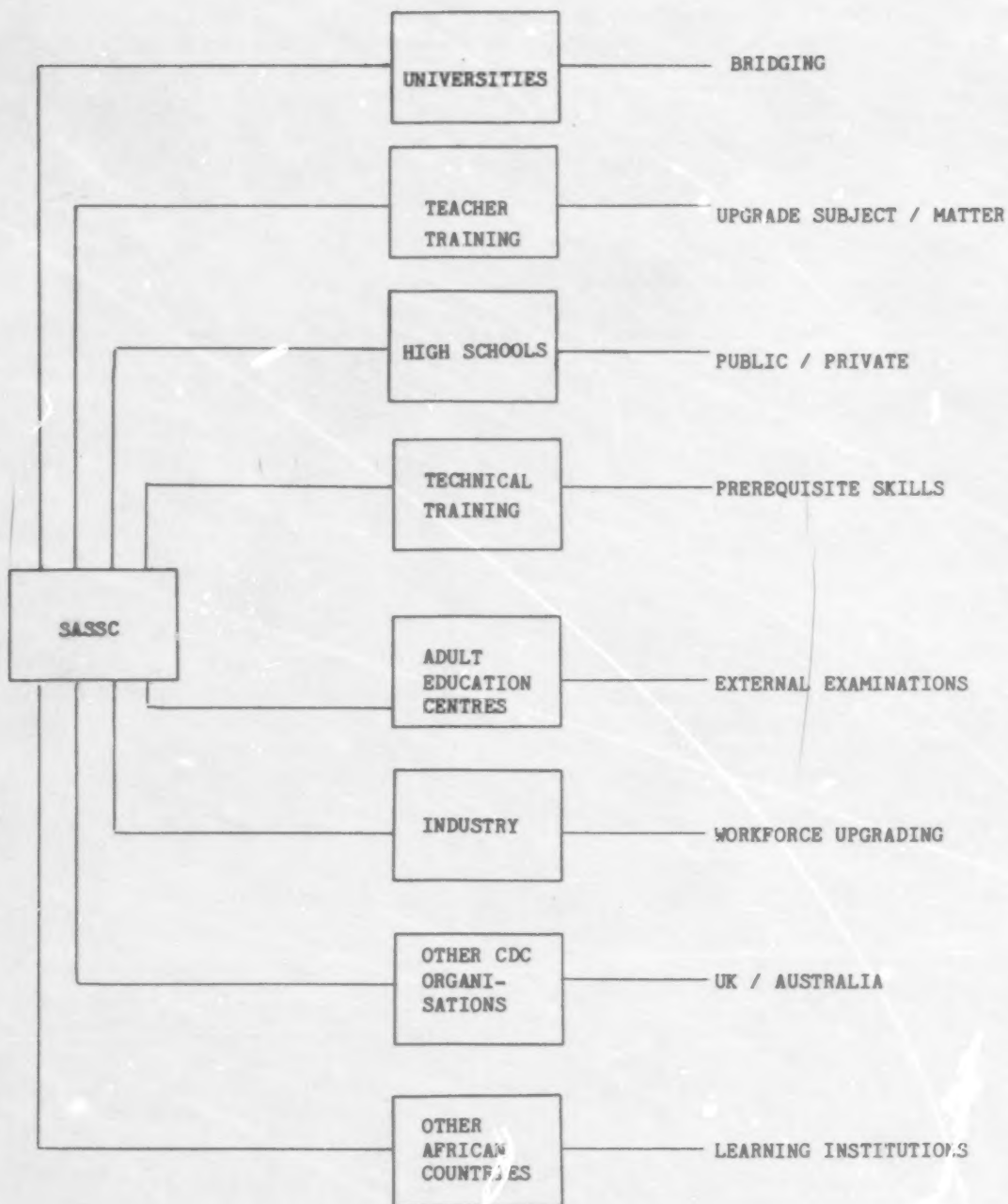


FIGURE 1 TARGET USERS OF SASSC CURRICULA

Initial development effort has concentrated on Physical Science and Mathematics. SASSC curricula in English, Biology, and Accountancy are being considered for future development.

Analysis of topics. Having targeted Physical Science and Mathematics as the subjects to be developed, the next step was to determine the scope and depth of coverage for the topics to be taught. These determinations were based on an analysis of the secondary school syllabi established by each of the national and provincial examining bodies. Because these syllabi are nearly identical in their requirements, the Joint Matriculation Board syllabus was used as the primary source.

The SASSC Physical Science and Mathematics Programmes each consists of four curricula corresponding to the sequence followed in the secondary school syllabi. Each curriculum is composed of a number of courses. There are a total of 24 courses in SASSC Physical Science and 13 courses in SASSC Mathematics. Table 1 lists the courses comprising the curricula in each programme.

During the design phase each course was further broken down into modules corresponding to major units of study. Finally, each module was subdivided into a number of instructional units corresponding to individual instructional objectives. The curriculum structure now has a total of 109 modules and 310 instructional units in Physical Science and a total of 94 modules and 244 instructional units in Mathematics.

Design Characteristics of the SASSC Curricula

The analysis of subject areas into courses, modules and instructional units was a major task of the design phase. Other tasks included design of a testing/record-keeping system for managing the individualised study of the curricula and planning the learning resources to be used in delivering instruction.

PLATO learning management as a testing/record-keeping system. One of the most important applications of computers to instruction is in the area of managing the instructional process. This application, known as computer management of instruction (CMI), involves using the computer to :

- administer and score tests to determine students' levels of mastery of course content
- diagnose areas of weakness and prescribe appropriate learning resources for un-mastered material, and
- store records of student performance for use by the student, instructor, and the CMI system.

These functions of CMI are described in [6].

One of the most important design characteristics of the SASSC curricula is that they make full use of the extensive CMI capabilities of PLATO learning management (PLA), Control Data's CMI system.

TABLE 1

CURRICULA STRUCTURE FOR SASSC
PHYSICAL SCIENCE AND MATHEMATICS STD. 6-10

<u>SUBJECT AREA</u>		
<u>CURRICULA</u>	<u>PHYSICAL SCIENCE COURSES</u>	<u>MATHEMATICS COURSES</u>
Std. 9-10 HG & SG	Mechanics Electricity Light Atomic Theory Chemistry	Algebra Trigonometry Geometry Vector Algebra
Std. 8	Light Sound Heat Electricity Atomic Theory Chemistry	Algebra Geometry Trigonometry
Std. 7	Nutrition Respiration Water Nature Conservation Mechanics Electricity Chemistry Waves	Algebra Arithmetic Geometry
Std. 6	Biology Atomic Theory Chemistry Mechanics Electricity	Number Theory Algebra Geometry

PLATO learning management provides for modular design of individualised courses and allows detailed diagnostic testing of student mastery of objectives in each module. If a student demonstrates mastery of all module objectives, he or she can by-pass the instruction in that module and move on to the next.

However, if a student is unable to earn a passing mark on the objectives tested in the module test, PLATO learning management prescribes appropriate learning resources for the individual to study. Only resources teaching un-mastered objectives are assigned. When the student has completed study and is ready to take another test, PLATO learning management selects new test items from the available pool and re-tests the student's mastery.

This cycle of testing, prescription of a study assignment, and re-testing continues until the student has demonstrated mastery of all module objectives. When module mastery has been attained, the student proceeds to the next module. PLATO learning management keeps detailed records of individual progress through the modules of a course and the courses of a curriculum. These records are available for use by the individual student or by the course instructor.

Use of PLATO lessons and text references as learning resources. It was determined during the design phase that the testing and record keeping requirements of the SASSC curricula would be met through use of PLATO learning management. It was also decided that the learning resources to be used would be a combination of PLATO assisted learning (PAL) activities (i.e., PLATO lessons) and reference to existing school textbooks. Other existing, individualised media such as video-tapes were to be considered and used where appropriate.

With these major design characteristics established, the project team moved on to the next phase of activity : Development.

DEVELOPMENT OF SASSC PHYSICAL SCIENCE AND MATHEMATICS

Development of the SASSC Physical Science and Mathematics programmes has been divided into two phases : Phase I and Phase II. These are illustrated in Figure 2. A discussion of the major activities in each phase is given below.

Phase I Development

The selection of subject areas, analysis of subjects into courses, modules, and instructional units at each school level, statement of instructional objectives for each instructional unit, and the establishment of PLATO learning management structures for each curriculum were all accomplished during the design phase. As shown in Figure 2, the tasks comprising Phase I development include : identification and selection of existing learning resources, development of test questions and question feedback messages, entry of the test questions into the PLATO learning management structures for each course, and completion of an edit/revision cycle for all Phase I materials.

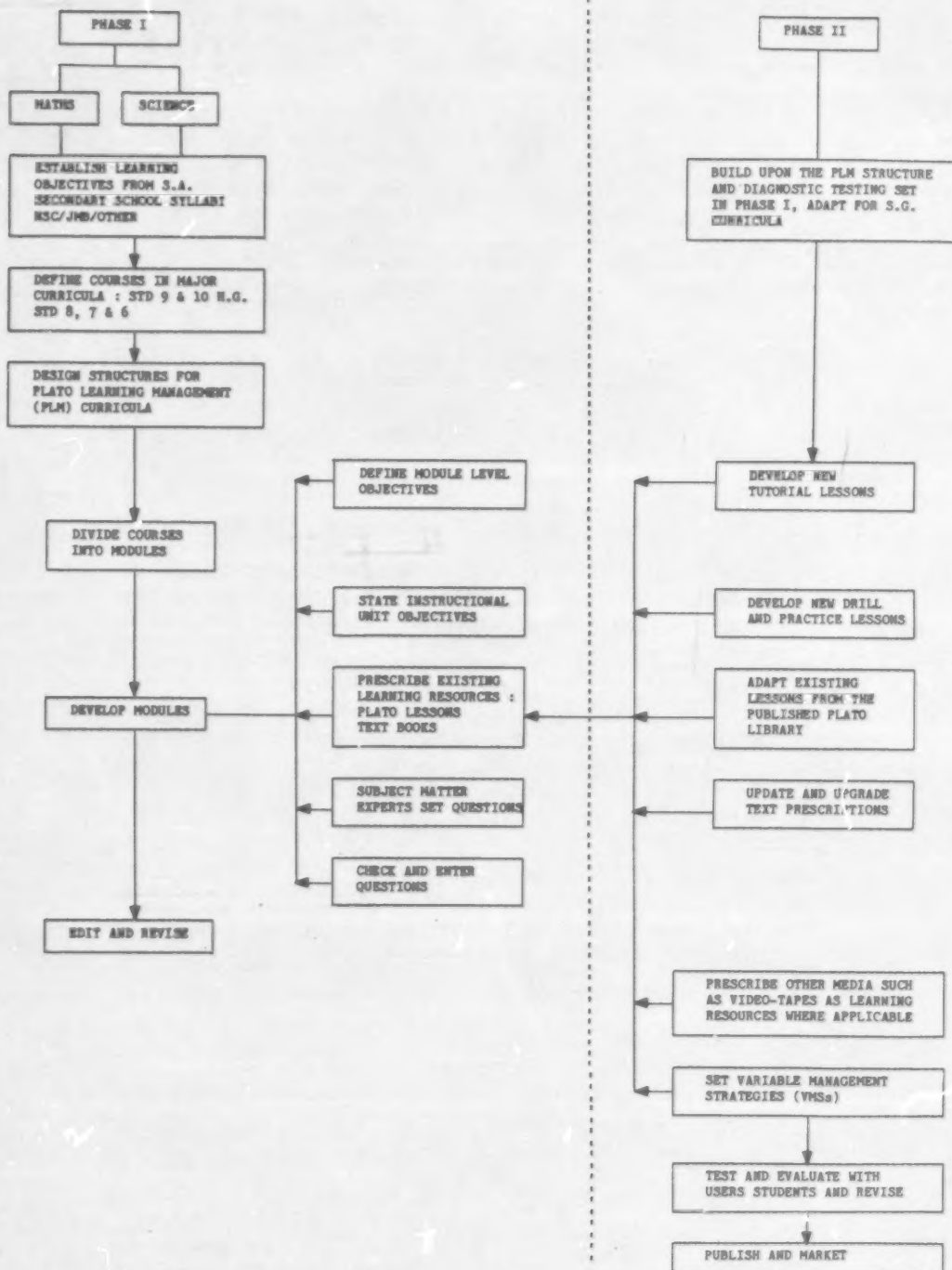


FIGURE 2 SASSC DEVELOPMENT PROGRAMME

The overall aim of Phase I is to develop computer-managed curricula that combine excellent diagnostic testing and the best of available, existing instructional materials.

Identification/selection of existing learning resources. A large number of PLATO lessons in academic subjects have been published by Control Data Corporation and are available for use in South Africa. One of the first tasks of Phase I development was to review the relevant ones of these published lessons to determine their fit to the design requirements of SASSC Physical Science and Mathematics. The most suitable of these were selected for use as learning resources in the SASSC curricula. In addition, readings in South African textbooks appropriate to each instructional objective were identified and entered into the PLATO learning management structure as learning resources.

Development and entry of test questions. PLATO learning management allows on-line testing and scoring. Question types currently supported include : multiple choice, true/false, matching, numerical entry and short answer. Graphics may be used in association with any of these types.

The student keys in or uses the touch panel on the terminal screen to select his or her answer to each question. When the student presses the ANS key, the response is judged according to preset criteria, and a mastery or non-mastery message is displayed at the bottom of the screen.

The SASSC curricula require several thousand high-quality test questions distributed among the various instructional units. Most of these questions are being set by qualified and experienced local teachers who are currently teaching mathematics or physical science. These Subject Matter Experts (SMEs) have been selected both for their expertise in the content to be taught and for their knowledge of the target population. Additional questions are being adapted from past matriculation exam papers. All questions are written on specially-designed forms to simplify review and entry into the PLATO learning management structure.

The questions are entered into PLATO learning management by clerical personnel. The skills of programmers, mathematicians, or scientists are not required for this task.

Edit/revision of test questions and strategies. Questions are reviewed by subject-matter knowledgeable personnel prior to their entry to PLATO learning management. Items which fail to meet the requirements of the design are revised or discarded. A further review is made after entry on line to detect and correct any typographical or keying errors and to verify the appropriateness of the mastery and non-mastery feedback messages.

Phase II Development

Phase II development is intended to build upon the basic structure established in Phase I. Although the Phase I level materials are sufficiently complete to be "usable" in controlled settings, the Phase II level curricula will have several added features.

The Phase II enhancements, summarised in Figure 2, include : development of new tutorial and drill and practice PLATO lessons, adaptation of existing lessons, addition of text and audio-visual learning resources, and establishment of additional management strategies to increase flexibility in use.

Development of new lessons. Even though all appropriate existing published PLATO lessons will have been used in completing Phase I development there will remain many instructional units for which additional PLATO assisted learning lessons will be desirable. One of the major activities in Phase II is the development and programming of new PLATO lessons.

Some lessons will be tutorial in nature. They will present new material in a way which requires frequent student interaction. Response-contingent feedback and branching can be used to make the lessons responsive to individual student needs.

Tutorial lessons will be designed and developed by SMEs in accordance with the overall curriculum design. They will be programmed by members of the project team.

Other lessons will take the form of drill and practice exercises. These lessons assume that the material has already been presented through some other learning resource (e.g., tutorial lessons and reference readings) but that additional practice is required to instill full understanding. The content for drill and practice lessons typically consists of approximately ten problems of varying levels of difficulty together with appropriate hints and feedback messages. SMEs prepare the content according to a set of prescribed format guidelines. The content is "programmed" by clerical personnel or beginning programmers.

Adaptation of existing lessons. Another enhancement planned for Phase II is cultural adaptations of existing lessons. Minor changes in spelling, terminology, and use of units will make existing lessons more effective for use in South Africa.

Addition of text and audio-visual learning resources. As Phase II development progresses the project team will investigate use of additional or upgraded reference readings. Audio-visual programmes may also be added to the learning resources under control of PLATO learning management.

Addition of management strategies. A further enhancement is the addition of management strategies to increase flexibility of the curricula for various user groups. For example, one management strategy will require users to progress from module to module and from course to course in a strict hierarchy. Mastery of one module or course will be required before proceeding to the next. Another management strategy will allow persons who have already studied one or more topics in school to revise them at any time without regard to hierarchy. Still other strategies will enable students to revise an entire year's work (for example, that in standard 8) through a series of modules designed to provide an overview.

Such overview management strategies will enable a student to prepare for later work with a minimum of time spent in revision.

A related feature planned for Phase II is the use of special on-line placement tests to determine which curricula (e.g., standard 8, standard 7, etc.) is most appropriate for a particular individual. These placement tests will assure optimum placement in the programme so students neither waste time repeating material or experience frustration with material for which they are not adequately prepared.

CURRENT STATUS AND FUTURE PLANS

The development of the SASSC curricula is expected to be an on-going, multi-year programme. Several of the courses in Physical Science and Mathematics have reached Phase I completion and are now in Phase II development. Other courses are still at Phase I level. Development at Phase I and Phase II levels is proceeding concurrently for different courses in the programme.

As Phase II development is completed for various courses, they will enter the formative evaluation phase of the overall development process. This is expected to include peer reviews by quality assurance SMEs and small group pilot evaluations with members of the target population. Needed revisions will precede formal publication and distribution.

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SECOND LANGUAGE LEARNING AND COMPUTER-ASSISTED LANGUAGE INSTRUCTION (CALI)

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ABSTRACT

In view of the contradictory judgements of CALI and in order to assess the merit of these judgements, second language teaching principles which accumulated through varying second language methodologies will be isolated and CALI evaluated within this framework.

Direct Method

- 1 Second language teaching should teach language, not about it;
- 2 it should give precedence to primary language skills i.e. hearing and speaking;

Audio-Lingual Approach

- 3 it should present language items in structures;
- 4 it should provide a large amount of language drill;

Transformational-Generative Linguistics

- 5 some deductive teaching of grammar rules is necessary;
- 6 language is generative, free expression should be allowed;

Communicative Approach

- 7 drills should be meaningful;
- 8 instructional material should be adapted to learner's needs;
- 9 content should be presented in context;
- 10 communicative use of language should be taught;
- 11 discourse should form the instructional material;
- 12 the culture of the target population should be part of the content;

Individualized Instruction

- 13 second language should be individualized;
- 14 all technological aids should be implemented.

CALI can meet the majority of the requirements of current second language viz. no's 1,3,4,5,7,8,9,11,12,13,14. This is not reflected in existing CALI programs. Many are still written largely in the grammar-translation method.

CALI can not teach the generative use of language or communicative competence. These could be viewed, however, as an advanced stage of second language learning.

INTRODUCTION

On the theme of L_2 teaching and CAI contradictory notes have been sounded over the past number of years.

On the one hand one hears, "The computer may turn out the most useful and versatile tool in L teaching" (Clutterbuck, 1929). Nelson et al. (1976) say "Workers in Computer-Assisted Instruction have long felt that languages were among the subjects to which it was most suited".

On the other hand Farrington (1981) says, "It runs counter to much current thinking in the field of language learning and if CAI were to be adopted on a large scale ... it is possible that it might favour a reordering of priorities that many teachers ... would regard as retrograde and mistaken." Even less optimistic is the verdict of Littlewood (1974) "... the nature of language makes it intrinsically unsuitable for treatment by a full programmed course. (CAI is here considered as a development of PI.) "Language, as a means of communication, bearing freely the meaning that the speaker intends, is beyond the scope of programmed instruction, which lacks the flexibility and adaptiveness on which such interaction depends."

In order to arrive at a reasoned evaluation of the respective merits of these judgements a brief survey of 'current' L_2 teaching methodologies seems indicated. In the second place the L_2 principles which evolved from these methodologies will be summarized. This paper will subsequently attempt to assess Computer-Assisted Language₂ Instruction within this framework.

1. L_2 Teaching Methodologies

1.1 The Grammar - Translation Method

Based on the traditional method of studying non-communication languages like Greek and Latin, this method was used for centuries. The rules of the language were taught in the MT. Learners were subsequently given the opportunity to apply them in translation exercises.

Long lists of vocabulary items and expressions, often with a low frequency rate and usually without any contextual relation, were memorised. The method concentrated further on literature and written language (Askes, Robinett, 1978, Hill, 1967). It succeeded in teaching the ability to read and write the target language. It taught about language but failed to induce learners to use language for communication.

This method was gradually discarded as new norms for knowing a language emerged. "A person knows a language" Lado said "when he can use its structures accurately for communication at will, with attention focused on the content, recalling automatically the units and patterns as needed and holding them for a normal span at conversational speed." (Askes)

1.2 The Direct Method

The advent of the Direct Method at the turn of the century, meant a major breakthrough in L_2 teaching. Based on the thesis that a L_2 is learnt like the L_1 , it insisted on using the target language in practice, instead of theorizing about it. It emphasized furthermore the sentence as the linguistic unit instead of the word. Grammar rules were to be learnt inductively and the MT was excluded from all teaching. Meaning was established directly in the L_2 by means of mime, concrete objects or actions.

Palmer's objection to the method was that it failed to teach meaning and to exclude the MT. Learners still translated subconsciously (Askes).

Furthermore the method was too unstructured for L₂ teaching. As too many structures occur in natural speech, structures and vocabulary need to be graded according to frequency, utility and teachability (Hill, 1967).

1.3 The Audio-Lingual Approach

Based on the behaviourist thesis that language is behaviour, this approach views language learning as a matter of acquiring a set of habits by means of stimulus-response conditioning (Farrington, 1981). It puts the emphasis on listening and speaking skills as central to the acquisition of the L₂ (Askes).

Instructional material was drawn from incidents in real life instead of from literature and presented in authentic situations, usually in dialogue form (Askes). Instructional material was graded according to frequency (Hill, 1967). New items were presented in structural sentences and grammar rules were taught inductively (Robinett, 1978). Structures differing from the MT received particular attention (Askes).

Language drills were a distinctive feature of the beginners' stages of this approach. Structural sentences were practised systematically and abundant opportunity was provided to reproduce them automatically (Askes).

Extensive use was made of all available technological aids - the language laboratory is the product of this approach.

The strength of this method is the ability learners acquire, even with a limited vocabulary, to understand and use language segments at normal talking speed in language situations (Askes).

The disadvantages which led to its rejection, were the mechanical reproduction of the memorized structural segments without real understanding, the inability to utilize the segments in new contexts and the monotony of the drills (Askes).

1.4 The Transformational-Generative Linguists

Though these linguists did not advocate a particular method, the insights re L₂ teaching which they contributed need to be mentioned.

They claimed recognition for the innate capacity of humans to learn language and create utterances never heard before. They accepted errors as part of the learning process, and stressed the importance of meaning. Lastly they advocated a reasoned application of rules i.e. deductive approach to grammar teaching (Robinett, 1978).

1.5 The Communicative Approach

Linguists have currently become increasingly concerned with the characteristics of language as an instrument of social communication. "L₂ learners, to be proficient, must know not only the basic structural principles of the language (viz. have linguistic competence). They must also have communicative competence, viz. know how to use sentences in performing acts of communication, and how to combine them to create coherent passages of discourse (Allen, Widdowson, 1975). Their utterances must be appropriate on many levels - they must conform to the speaker's aim, to the role relationships between the interactants, to the setting, topic, linguistic context etc. (D Hymes, 1972).

This aim has led in the first place to a reconsideration of the 'content' of L₂ courses. Syllabuses were outlined which contains not a selection of linguistic and lexical items, but language functions i.e. the uses that one makes of language and language notions or concepts (Allen, Widdowson, 1975). Instructional units in a communicative syllabus became therefore "Apologizing, Introducing oneself, Requesting" instead of the linguistic items, "Present Simple Tense, Relative clauses" of the Grammar - Translation or Structural - Situational approaches. The functions selected were based on learners' communicative needs, viz. those functions that they need for their communicative activities (Morrow, Johnston, 1981).

In the second place, it required a methodology significantly different from traditional methodology. According to Rodgers (1978) the following features distinguish this approach:

- more emphasis on message meanings, less on formal structures;
- more emphasis on communicating, less on correctness;
- more emphasis on problem solving, context interpreting strategies, less on modelling, mimicry;
- more emphasis on creating content as well as utterance, less on using set content and situation;
- more emphasis on student-student interaction, less on teacher-student interaction;
- more emphasis on extra-linguistic devices - such as paralinguistic (gesture, tone), less on linguistic content;
- more emphasis on physical teaching environments encouraging group participation, less on physical arrangement favouring teacher attending;
- more attention on positive language transfer - less on first language interference.

The main limitation of this approach is that it presupposes linguistic competence. Alexander says (1981) "Unless a learner can operate the system he has no chance of achieving the ability to communicate in true social terms, and 'operate the system' means controlling the grammar." The communicative approach therefore should be regarded it seems, as a more advanced phase of L₂ learning. Alexander (1981), Swan (1981), Scott (1981) and other linguists question its ability to teach successfully at the beginners' level.

Its main contribution it seems, is to emphasize dimensions of L₂ teaching neglected in previous approaches. These dimensions however should not be mistaken for the full spectrum of L₂ teaching. Swan (1981) thus advocates a number of different syllabuses operating simultaneously, the notional and functional syllabuses being only two of them.

1.6 Individualization of Instruction

Lange and James (1972) identify individualization of instruction as the most recent trend in L₂ or FL Education, in other words a switch in focus from language learning to the language learner and his needs.

Rodgers (1978) lists the differences in language learner needs that necessitate individualized instruction.

Students learn at different rates of speed;
 they learn through different media;
 they are competent in different kinds of educational content;
 they learn through different styles of content organization;
 they respond differently to different forms of feedback;
 they perform differently in different group arrangements;
 their learning efficiency varies differentially according to the time
 and place of study.

All these differences should be accommodated by instructional strategies and materials. Procedures for measuring and matching students and activities and a management system to make that possible (Rodgers, 1978) are therefore needed.

2. Principles of L₂ Teaching

Throughout the apparent fluctuation of L₂ teaching from one extreme to the other, a consistent, coherent evolution in thought about L₂ teaching was in progress. Meaningful insights, once established, were maintained by successive methodologies even though emphases often changed radically. "Every method" Close (1977) says, "has made an important contribution to the science - art of English language teaching".

Summarized, the contributions made by the different methodologies constitute a framework of L₂ teaching against which CALI can be evaluated.

Direct Method

- 2.1 A L₂ is acquired by practising/using the language - not by learning about the language.
- 2.2 Hearing and speaking the language are primary skills and should precede reading and writing it.
- 2.3 Some selection and grading of instructional material is necessary particularly for initial L₂ teaching.
- 2.4 The sentence and not the word is the linguistic unit - items should therefore be presented in sentence structures.

The Audio-Lingual Method

- 2.5 Instructional material should be drawn from real life, not from literature. The dialogue seems a successful way of presenting it.
- 2.6 A vast amount of language drill-conditioning is required to internalize structures to the point where they can be reproduced automatically.

The Transformational-Generative Approach

- 2.7 The practice of linguistic forms without meaning is counterproductive - drills should therefore be meaningful.
- 2.8 Language is generative; therefore learners should not merely reproduce but have ample opportunity to create new utterances.

- 2.9 Correctness of utterances must be viewed with greater flexibility.
- 2.10 Grammar rules should to some extent be taught deductively.

Communicative Approach

- 2.11 Knowing the structures is not enough, but the use of language for communication must be acquired. Activities involving learners in communication should therefore be presented.
- 2.12 Instructional material should be adapted to learners' linguistic needs.
- 2.13 Sentence patterns and vocabulary should be taught contextually in meaningful situations.
- 2.14 The last instructional component is that of culture i.e. the development of an awareness of the values and behavioural patterns of the target community (McEwen, 1977).

Individualized Instruction

- 2.15 The learner and how he learns is more important than the teaching. Learners' learning strategies should therefore be accommodated as far as possible.
- 2.16 As many technological aids as possible should be implemented.

3. Evaluation of CALI in the light of above principles

Establishing the extent to which these principles can be realized by CALI should result in a more reasoned verdict on CALI.

3.1 L₂ learners should use language in practice, not learn about it

When Farrington (1981) states, "The computer tends to teach about language rather than teach the language itself", he seems to base this assessment on a survey of existing CALI programs which he finds "orthodox, ordinary and ... alas, often mediocre material" (1981). It is unfortunately true that many CAL₂I programs are still modelled on the traditional grammar-translation method with deductive presentation of rules, followed by translations of inter alia, CBI in Elementary Hindi (Kachru et al., 1981); CBI program for the Teaching of Modern Hebrew (Cole et al., 1981); PLATO Esperanto Materials (Sherwood, 1981); Computer-assisted Instruction in Latin and English vocabulary development (Scanlan, 1981). It should be pointed out however that these programs are intended as supplementary materials, where the communicative skills are reserved for the class-room situation or the courses are taught for non-communicative purposes.

However this does not apply to all CALI materials. Materials are being written that prove that the computer can teach language. T. Johns (1980) describes programs with a generative approach to L teaching; R. Dixon (1981) describes English lessons for International students where, in addition to the traditional grammar exercises, dialogues are simulated to teach language usage.

S. Nelson et al. (1976) describe Desch's German reading program where the student asks questions about material he does not fully understand. They also describe Ward's word-order judging routine where the sentence generated by the student is corrected and analysed progressively by supplying the grammar rule that explains the correct use. At the Language Institute of the University of Stellenbosch an English program for adult beginners in industry is being designed that attempts to teach usage. It presents language in dialogues, made meaningful by means of graphics, and presents the spoken and written symbol simultaneously. Ample opportunity for production of both sounds and forms is provided and learners are then tested on mastery.

This account of more recent CALI materials does not claim to be other than fragmentary. Its purposes is to establish that the computer can teach language and not only about language. It is, however, only beginning to explore its potential in that direction.

The addition of an audio component to the computer, supplying the spoken equivalent of the written text, providing opportunity for students to repeat what they hear, as often as they choose, is clearly essential for more communicative CALI.

The feasibility of such components is no longer in question. Marty (1981) describes several models that are in use, inter alia, an audio device using a magnetic deck at the University of Illinois speech synthesizers, the "Spiritus" tape deck manufactured by Fowler Associates Inc., Santa Anna, California. Clutterbuck (1979) says "Already voice input and output is being successfully developed. Within a very short time computers will be able to accept spoken German sentences. Simple conversation using carefully prepared basic dialogues is well within the realm of possibility in the same time estimate".

3.2 Precedence of listening and speaking skills

As has been pointed out above, the audio component makes simultaneous instruction of listening/speaking and reading/writing skills possible. Even the evaluation of the spoken utterance seems no longer an impracticability, cf Clutterbuck above. Free oral expression however, with its unanticipated response, does not seem within the scope of the computer (Marty, 1981).

3.3 Design Decisions

Implementation of the following L₂ teaching principles is not dictated by the computer, but is a design decision taken by the materials designer. Failure to implement them should be ascribed therefore not to a limitation in the capabilities of the computer, but to limitations in the design of the programmer.

- 3.3.1 Instructional materials should be selected on the basis of a learner's needs analysis (vide 2.12)
- 3.3.2 instructional material should be graded (vide 2.3)
- 3.3.3 instructional material should be drawn from real life and not from literature (vide 2.5)
- 3.3.4 it should be presented 'contextually' in 'meaningful' situations (vide 2.13)
- 3.3.5 cultural awareness and the behavioural patterns of the target population (vide 2.14) should be developed
- 3.3.6 the instructional unit to be taught is the sentence, not the word.

By reason of its ability to present simultaneously graphics, writing in speech bubbles and audio, the computer offers exciting possibilities for presenting dialogues.

3.4 Language Drills

The necessity for a vast amount of language drill in L_2 learning has been stated. Robinett (1978) cites the following linguists in support of this: Ney (1968), Brown (1969), Schultz and Derwing (1978), Bollinger (1968). The drills implemented in the Audio-Lingual Approach failed for two reasons: they did not communicate meaning and they were exceedingly tedious.

In the first place the computer is able to supply the meaning of drills by means of graphics. In the second place, it is able to alleviate the boredom of drills by involving the learner in meaningful interaction. Particularly involving the learner in competition with the computer, by casting drills as games, has proved successful. Tedium is further avoided by providing immediate feedback on learners' attempts to use the language. The computer can also direct learners to the areas where they need practice and allow them to bypass familiar material - one of the most common reasons for frustration and boredom.

Even more important, it is itself not bored by the interminable repetition of language items. Teachers often communicate their own boredom to learners. Further, drills need rigid and narrowly defined responses, well suited to computerised progress (Farrington, 1981).

3.5 Deductive teaching of rules

The computer's natural aptitude for this kind of lesson probably accounts for the fact that so many existing CALI programs are deductive grammar rule lessons. The computer makes possible a highly sophisticated analysis of learner responses, closely resembling the personal interaction between teacher-learner, where each error is analysed in turn and the learner referred to the relevant grammatical structures. Two such programs have been described above by Nelson (1976) vide p. 6. F Marty (1981) describes similar techniques used in French lessons at the University of Illinois.

3.6 Individualized Instruction

The computer could provide the answer to many of the problems of the conventional classroom situation such as the high student-teacher ratio, the high number of contact hours needed for L_2 teaching, the inability to provide adequate feedback in a 1/20 relation, the onerous task of conducting drills, the low percentage of interactive participation (Nelson, 1976). Rosenbaum (1969) calculates that in a basic language course the typical number of interactions per teacher-student will not exceed four or five in a fifty minute lesson.

It could therefore reduce the number of class sessions, could relieve both teacher and pupils from the time-consuming classical drills, allow students to practice and progress at their own pace and free teachers for communicative activities (Nelson, 1976).

Its branching possibilities can offer learners a choice of learning strategies. The French programs described by Marty (1981) provide an illustration of such techniques. Learners may select a presentation of the rules at any moment, may evaluate their own performance.

It can eliminate the chore of preparing tests on grammatical skills. It can prepare remedial, revision or advanced programs on an individual basis (Clutterbuck, 1979). In addition it can compile and produce information about individual learners to be used in developing appropriate instructional strategies; it could help generate instructional schedules; match students to teachers and instructional materials; evaluate learning programs and test individual competencies of learners and teachers (Lange, 1972).

3.7 Communicative use of language

The computer cannot initiate, or evaluate communicative activities. It cannot cope with the distinctive features of communicative interchanges viz. the information gap, the unanticipated response (Morrow, 1981). It is like-wise unable to implement student-student interaction or to promote a physical teaching environment encouraging group participation. Neither can it teach the paralinguistic features of language. However, the point has been made that linguistic competence and communicative competence seem to be progressive stages on one continuum. Linguistic competence precedes communicative competence and must be attained before real communication is possible. The computer can contribute to achieving linguistic competence and the more advanced skills can be reserved for the classroom situation.

3.8 Free generation of language

Evaluation of the freely generated response, either oral or written, is beyond the scope of the computer.

3.9 Error

CALI with its emphasis on mastery learning, tends to give greater importance to accuracy than to fluency, which it cannot assess (Farrington, 1981).

Conclusions

Linguists have on the whole been circumspect in the claims made for CALI. Possibly the Language Lab's rapid course from philosopher's stone to white elephant has had a sobering influence on enthusiasm.

However, in the light of the above examination, it can be claimed that the majority of current L_2 teaching principles can be accommodated adequately by the computer. It cannot teach communicative use of the language but, as has been pointed out, communicative use of the language should be seen as an advanced phase on the continuum of language₂ teaching which could be reserved for the classroom situation.

It also seems clear that L_2 materials designers have so far not yet fully exploited the potential offered by this remarkable tool.

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DEFINING A CONTEXT FOR COMPUTER-BASED EDUCATION

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ABSTRACT

The paper gives a brief overview of the ideal role of the University of the Western Cape (UWC), a community-oriented university. It furthermore illustrates how blueprint academic planning, backed by large-scale pilot studies, resulted in a different instructional configuration, which included the implementation of computer-based education (CBE).

A critical appraisal of computer-based education and a review of its implementation at the UWC are offered. Since the University of the Western Cape was the first institution in Southern Africa to implement CBE, its work in this field can serve as a guideline to other institutions - especially in view of the fact that the UWC Instructional Computing Programme is at present the most extensive undertaking of its kind in the world.

DEFINING A CONTEXT FOR COMPUTER-BASED EDUCATION*

Introduction

It has been said that the decision to innovate can best be likened to religious conversion; it is a sudden insight usually supported by encouragement from a large group of peers. This statement certainly does not apply to universities as they have acquired the reputation of being as dynamic as a cemetery with a hierarchical structure which cannot be easily rendered down into straightforward and predictable components.

On the other hand there is of course the danger of making a virtue of innovation. Edmund Burke aptly warns that "to innovate is not to reform". There is only a thin demarcation between purposeful innovation of lasting value, passing modishness and gimmicky fads. The coinage of terms such as "computerphobia" and "contagious computerization" is proof that computer-based education (CBE) is also not free of blame.

The purpose of this paper is to give a brief account of the carefully considered decisions which led to the implementation of CBE at the University of the Western Cape and a compact overview of its present status on our campus.

The University of the Western Cape

The University of the Western Cape (UWC), which is only some 30 kilometres away, is now in its 23rd year of existence. It serves mainly the Coloured population,⁽¹⁾ the majority of whose members are to a large extent culturally deprived and caught up in poor socio-economic conditions.⁽²⁾ At school level this state of affairs manifests itself in a high attrition rate. Of the pupils who started school in 1963 and who then completed thirteen years of schooling, the percentage for Coloureds compared with Whites for example, is 4 percent as against 85 percent.⁽³⁾ What makes the situation even more appalling is the acute shortage of professionally qualified teachers, especially in mathematics and the sciences.⁽⁴⁾ And the situation is deteriorating.⁽⁵⁾

Meeting the needs of a deprived community

From these facts the proper role of the University of the Western Cape should be clear if it is to meet the educational needs of the community it primarily serves. But unless the media used for conveying education are adapted to meet these requirements, the gap between educational needs and the degree of their satisfaction will increase. For many years the inherited attitudes, mentality and routine of traditional educational practice hindered the UWC in the performance of its proper function.

Paradoxically the UWC was for years the fastest growing university in the Republic with a growth rate of between 17 and 19 per cent, yet its output in graduates was pitifully low. In the Faculty of Natural Sciences, for example, only five per cent of the students completed their course of study in the prescribed three years. While the demand for further education increased, the mechanisms for improving the delivery of education did not exist. In this way the imbalance between normative and operational modes grew wider.

Academic planning

Until the establishment of a unit for academic planning two years ago, policy formulation was not centralized but done rather haphazardly by appointed committees which in the majority of cases neither had the time nor the expertise to undertake active research and prepare elaborate documentation. Consequently the changes were peripheral and the status quo remained untouched.

* Information on the practical implementation of computer-based education at the University of the Western Cape is largely based on my paper entitled "Educational Technology and the Implementation of Computer-based Education", to be presented at the Eighth International Conference on Improving University Teaching scheduled for July 1982 in West Berlin.

The need for such a planning unit got its final impetus, strangely enough, through the possible introduction of computer-based education. When this issue was raised for the first time at subcommittee level, the need for in-depth documentation and dissemination of information became most apparent, this time on a much larger scale than ever before. There was also a long-felt need for the centralization and control of all audio-visual equipment bought over a period of twenty years, with subsequent guidance on their applications.

All this resulted in the establishment of a Teaching Centre with academic planning as its *main* concern and not, as is so often the case, mere media administration. At the outset, the greatest task of the Teaching Centre was to design a framework for future academic development, including the possible implementation of computer-based education.

Establishing a meaningful context for CBE entailed the large-scale restructuring of the existing educational system.

Instructional design models

The common components of instructional design models are usually outlined by way of a sequence of steps to be followed, starting with the assessment of needs, consideration of alternative solutions to instruction, formulation of a system and identification of constraints, ending with the development of materials and procedures for installing, maintaining and periodically repairing the instructional programme.⁽⁶⁾ Perhaps these components, simple as they may seem, have become too complicated to be viable in practice.

The theory that the prescription of a series of steps when executed in sequence results in predictable learning outcomes has not lived up to expectations, for the simple reason that it is so extremely difficult to make an empirical comparison of one instructional design model with another when the component which is being researched is taken out of context. On the other hand one encounters even greater problems when trying to examine an entire instructional design model.

This was the main reason why the UWC at no stage even considered the possibility of acquiring only two to three terminals on an experimental basis.

The University was so desperately in need of a totally different educational system that it had no option but to engage in blueprint planning, devised and finalized on the drawing board as it were. There was simply no time for lengthy research programmes.

This blueprint planning entailed policy-making on three levels:

- * normative policy, i.e. what ought to be done
- * strategic policy, i.e. what can be done
- * operational policy, i.e. what will be done.

But planning as such says very little unless it is turned into decisions.

Furthermore, any decision is only effective if it is translated into action.

The following thoroughly businesslike precautions, which we found very helpful, may serve as a guideline:

- * Create an environment in which decisions would flow as needed.
- * Make these decisions timely and responsive to the problem or opportunity they address.
- * Provide for coordination between the various decision-making levels.
- * Create a fertile environment for setting objectives to give the institution a continuous forward thrust.
- * Provide a communications system to keep the top hierarchy informed.
- * Conversely, provide the means whereby the ideas and ideals of the top hierarchy can be translated into action without loss of enthusiasm or intent.

The role of the instructional designer as agent of change cannot be over-emphasized, because modernization of an educational system means above all a reform in pedagogical attitude, which is the basis and essence of educational practice.

And although an institution is more than the sum of its parts, it *is* dependent on the sum of those parts. Whether we like it or not, heads of departments are the basic units which make up the decision-making network.

By designing a typology of attitudes the agent of change can plan his strategies accordingly. Such a typology covers various categories of attitudes, ranging from those who feel reactive, suffering from the somewhat worrying "good old days" and "teach as I was taught" syndrome, to those who act in a proactive way and want to make things happen. (7)

Within a university hierarchy three levels of academic discourse can be distinguished, viz. front-stage, (Council, Senate), back-stage (ad hoc committees) and under-stage (an undefined area where the main organizational functions of the institution manifest themselves) (8) It is at this latter level that the instructional designer, as agent of change, can best unfreeze fixed ideas.

The extent to which our strategic planning was effective, is illustrated by the fact that within four months after the issue of CBE was first raised on campus, an agreement was reached for the installation of sixteen PLATO^(R) terminals in April 1980.

The pre-planned implementation programme ran so well that a year later the University bought its own computer, added 48 terminals, and established two more PLATO laboratories.

Instructional theory

One may well ask whether the failure to translate the learning process into operational terms has not been the most limiting factor in our application of computers and other technological aids to assist learning. It has been forecast that the impetus for real progress in the 80's will come from those who best understand human learning theory and who can apply this understanding to the decision-making process of instructional design. (9)

I think the time has come for us to turn our research away from what has been called the long and sterile tradition of comparative studies to an investigation of the interactions between media, tasks and learners.

Every time a new medium of communication is introduced, the research task should be to describe how the system of knowledge sources and learning opportunities change. In this regard it goes beyond media and involves instructional and curriculum development. This may be the reason why there has lately been an increased emphasis on the design of material, including specific coding elements, rather than the mere selection of resources. In an article "Is Educational Technology in Phase?" Robert Gagné⁽¹⁰⁾ points out the importance of new developments, in particular in the areas of metacognition and the learner's prior knowledge. He goes on by stressing the following points:

- * Learners must be helped to perceive the structure of the content to be learned, which necessitates a careful task analysis by the teacher.
- * Learning and memory depend on the relationship between inherent content structure, the learner's prior knowledge, and the way in which new material is initially presented. Gagné stresses the lack of use by designers of the prior knowledge which students bring to the learning situation.
- * Provision should furthermore be made for the learner to comprehend the learning task. Much more might be done by giving learners greater insight into the learning process and giving explicit instructions on how best to master the materials.

None of the above, however, will materialize without reliable feedback, without a proper knowledge of students' achievements. Traditional pedagogical practice concentrates on the sort of presentation that serves cognition only and is able to estimate rather than measure its achievements. Evaluation should be such that it will reveal data and facts enabling us not only to analyze achievements but also to design and implement further steps, so that students' achievements reach the desired level. (11)

With renewed interest focused on the learner, a case could be made out for ways in which computer-based education, especially through computer-managed instruction, can be a powerful resource in terms of Gagne's three propositions.

A significant attribute of computer-based education, for example, is the fact that the student can break out of a linear sequence of material to recap or follow an alternative approach, which will allow him to change his route through the learning materials according to his own preferences.⁽¹²⁾ Linked to the system's report capability, which provides feedback on performance and progress to the student, the teacher and the instructional designer, a teaching-learning dispensation can be designed which will allow every individual student the best opportunity for maximum cognitive growth.

Action Research

Although the initial planning of a different educational system at UWC was done on the drawing board, it did not preclude a series of interrelated surveys conducted since 1980. The following few conditions and their subsequent outcomes give an idea of the flow of events:

1. Student background

<u>Condition</u>	<u>Outcome</u>
Apart from aptitudes and attitudes, the students' personal backgrounds were surveyed. For the first time it was ascertained that a large number of them lack the practical facilities conducive to study. For instance, 40 per cent do not have a study desk, 61 per cent do not have a reading lamp, and 40 per cent have no bookshelf. In addition, 34 per cent of the students travel to the University in an unreliable way, such as by hitch-hiking; for one out of five students it takes an average of two hours or more to travel to the University and back. In the majority of cases, furthermore, the parents hold blue collar jobs and the students are the first in their family to attend a university. Forty-one per cent of the students spend only from one to eight hours per week on their studies on average. This must be linked to the finding that at school the majority of students acquired a study pattern relying heavily on memorization immediately before tests and examinations. Such bad habits must, of course, be seen within the context of existing limitations at school level: - underqualified teachers, - poor school facilities, - outdated curricula and textbooks, - a poor teacher-student ratio, and - a lack of teaching aids and extra-mural cultural activities.	The data on the student milieu and the teaching-learning arrangement clearly indicated that students were desperately in need of <i>more time to learn, a positive learning environment and compensatory instruction</i> tailored to their particular needs. <i>Compensatory instruction</i> is not to be confused with <i>remedial instruction</i>, however. The teaching style of remedial instruction is defined by the assumption that the student has already been exposed to instructional materials and procedures which are known to be sufficient to permit the desired learning; since such a student has not learned within that normally adequate environment, a remedial environment must be created to meet his special needs. By contrast, compensatory instruction recognizes that the student has not yet been exposed to that "normally adequate" learning environment; its premise is that the educational system has failed to teach the student rather than that the student has failed to learn. Planning at UWC therefore required the Teaching Centre to provide clear and convincing documentation as to how CBE would provide the necessary compensatory learning environment.

2. Time-table

<u>Condition</u>	<u>Outcome</u>
Results from a study of formal lecture loads clearly indicated that the students were heavily overburdened - that there were students who spent more than 30 hours per week in a classroom. If one adds this amount of time to the time it takes a student to get to the campus, 40+ hours would be spent per week before the student even had a chance to study independently. At the same time it became apparent that instruction had become too manpower intensive - that a situation had been reached where the teacher was actually prohibiting learning, apart from spending too much time on teaching at the cost of research.	A proposal was passed allowing heads of departments to decide on how the 5x40 minutes formal lecture time would be utilized. Departments were henceforth free to implement a multi-media approach: formal lectures, tutorial discussions/seminars, CBE, learning laboratory sessions, personalized systems of instruction. The onus was thus placed on every head of department to design a teaching-learning environment best suited to his subject, his staff allocation and his body of students. This more flexible teaching schedule left the staff members with more time to develop courseware and engage in research, while the students were also in a much better position to arrange learning schedules to meet their personal needs.
The prescribed formula of 5x40 minutes of formal lectures per week per course per student was a serious stumbling block to the implementation of alternative methods of instruction.	In practice this arrangement would permit departments to adopt a more innovative approach to their particular requirements.
Whenever a department wanted to make use of methods of instruction other than the formal lecture (such as seminars or tutorial discussions) additional time had to be found. This led in turn to even more serious over-scheduling, so that a maximum number of periods per week per course per student had to be laid down.	

3. The gap between school and university

<u>Condition</u>	<u>Outcome</u>
For years on end there has been an awareness of an existing gap between school and university which must inevitably have a detrimental effect on student performance. However, no definite information was collected on the real nature of this gap, nor were ways of bridging it devised.	The Faculty of Natural Sciences took the lead at the beginning of the present academic year by having all first-year students work full-time on PLATO bridging material in mathematics, physics and chemistry.
Teachers took for granted what first-year students ought to know and based their teaching on that fallacious premise. This resulted in a very high attrition rate during the first semester.	Through PLM (PLATO Learning Management) it was possible to monitor student progress. For the first time the effects of inadequate education could be ascertained in real terms. For example: only one student out of the entire class managed to score 75 per cent in the chemistry course prescribed for Std. 8 pupils. We now know that the gap in knowledge is much wider than originally thought.
Further proof of the academic gap was the fact that those students who repeated their first year often turned out to be the top performers in the following year. This, again, confirmed the need for compensatory rather than remedial instruction.	

4. The entrance qualification

<u>Condition</u>	<u>Outcome</u>
Less than 15 per cent of all students who pass the matriculation examination obtain matriculation exemption. This has forced the University to give serious attention to the entire principle of entrance qualifications. Taking the social background and schooling conditions into consideration, the question emerged: Should the University rely solely on the schools to decide who is qualified for entrance, or should the University set its own criteria? The latter seemed worth investigating - especially since the issue also has immediate consequences for the undereducated adult who is debarred from university studies at a later stage in his life.	The University decided in principle to create alternative structures whereby students or adults who did not normally qualify for university studies would be allowed to register for a compensatory course of study which would qualify them for conventional enrolment. Especially in the case of a deprived community such an arrangement would in effect permit 'open access' to everyone with the necessary potential.

UWC Reality and CBE Potential

I have by now referred often enough to CBE. I suppose I need hardly mention the traumatic history which surrounds this instructional resource, the main reason being that computer technology has outstripped our ability to use it effectively.⁽¹³⁾

One has merely to read the Proceedings of the Third World Conference of 1981⁽¹⁴⁾ on Computers in Education to realize to what extent the applications of computers in education are:

- * still highly experimental
- * bound to projects and not to institutions
- * speculative in outcome.

In the Conference Proceedings, Gulati asserts that "developing countries are faced with the depressing result of ineffective utilisation of computers."⁽¹⁵⁾ He argues that the infrastructure required to support effective computer usage has not been fully recognised or understood in most of these countries. He also points to the fact that no good model exists, even in developed countries. He next suggests an integrated solution of modular type, adaptable in characteristics, which should provide feedback to the different developing countries so that these countries, moving from one stage of development to another in this area, are able to learn from one another's experience.

Model or Example?

Many persons feel that for situation A to be a "good model" for situation B there should be a one-to-one correspondence between critical components of the two situations. It would thus seem unlikely to them that the programme of a small, relatively young university in South Africa could serve as a model for established institutions in the RSA and other countries. I shall be conservative, therefore, and claim that what follows is not proposed as a model for the implementation of computer-based education. Because of the completeness and "success" of the implementation programme at UWC, however, it certainly qualifies as a relevant example. Moreover, the size and extent of the instructional computing programme at UWC make it the *only* example of a thorough commitment of computer-based instruction by any institution. At the very least, the discussion can highlight the issues to be resolved wherever CBE is at stake.

A guideline for the introduction of technology worthy of imitation is given by Grayson.⁽¹⁶⁾ I would like to express his thoughts in the form of three propositions:

- All planning must be aimed at overall programme effectiveness. Educational technology is not only the application of hardware, but it concerns essentially a systems approach whereby educational objectives can be achieved. As such it involves the application of scientifically tested principles of teaching and learning in a consistent and coherent manner.

- Technological hardware must be used as part of a new system, not as an addition to existing practices. The potential that technology holds for the individualization and personalization of instruction, thus allowing for more effective instructional patterns, can only be realized through organizational change.
- Media-based instruction has proved to be at least as effective as conventional approaches. This should be capitalized on. It is most promising in situations where teachers, materials, and facilities are lacking, or where traditional approaches have failed.

From what has been said so far about educational technology, the traditional teaching-learning arrangement at the UWC and the changes which have been brought about, it should be clear that the role CBE was supposed to play was essentially predetermined.

Of bytes and pieces

The decision in favour of a particular system was mainly based on four reasons:

1. The sophistication of the hardware supporting many instructional strategies. Whatever scepticism there might have been among staff members about CBE was partly alleviated when they realized that the system the University was to acquire was without comparison in terms of instructional application.
2. The involvement of the supplier in the educational field. The PLATO system was specifically designed for educational applications and the supplier, Control Data (South Africa), has shown its interest in the local educational field by starting the SASSC *Project in mathematics, physics and chemistry for matriculation students. This project is currently being carried out with the close cooperation and active participation of the UWC.
3. The availability of an extensive courseware library. This was perhaps the most decisive factor in favour of CBE. For an academic institution, however advanced its academic planning and infrastructure might be, to be the first and only institution to make an investment of more than 2 million rand in an instructional aid, is a giant step into an unknown world. The fact that staff members could beforehand ascertain for themselves what courseware was directly applicable or could be adapted to their fields of study, facilitated the final decision. It happened to be that courseware in mathematics and the sciences, areas of critical concern at the UWC, was substantial. The idea of immediate personal profit was very important in this regard.⁽¹⁷⁾ Teaching staff could see a distinct educational benefit in becoming involved in CBE.
4. The availability of consultants. As with any new educational venture, the duration and intensity of training covering all the various facets and establishing a core of locally trained experts is crucial to the success of the enterprise. This availability of experts of our choice for a period of up to three years was part of the formal negotiations. The idea was that every such consultant would orientate himself towards the specific educational environment and its needs, and above all train a key group of experts who would in turn train others and assume other infrastructural responsibilities. The criticism of Gulati in this respect then falls away: "Developing countries", he says, "are using different means to educate and train their personnel. These cover the facilities provided by equipment suppliers, attendance at courses arranged or organised by international agencies, setting up of training and educational facilities within the country, etc. The general feed-back on these is scarce, and where available is not very encouraging."⁽¹⁸⁾

A few words about the application phase itself. Grayson sees the application of technology in three distinct phases, evolving from a research stage to a developmental prototype stage to an operational stage.⁽¹⁹⁾ I differ with this approach. If your planning model makes provision for a specific instructional technology, any

application of that technology should be at such a scale that it *directly* addresses the envisaged goals. This was the reason why the UWC started off with 16 terminals - the largest initial installation of its kind at university level in the world.

To back this philosophy of operational research rather than experimental research there are the project reports on PLATO installations delivered at the Third World Conference on Computers in Education.⁽²⁰⁾ Some projects are, after years of action research, either not off the ground yet or have gone down the drain. What can be said of Einstein's theory of relativity, viz, that if he had first to prove it in practice, he would never have been able to postulate it, is quite appropriate in an educational context: once you have hypothesized what ought to happen, you should have the courage to go ahead.

Equally important is how the implementation of any new technology is looked upon by the teaching staff: whether the technology is looked upon as merely experimental in nature or rather as something which has come to stay as our own, and should therefore be used to its fullest extent. Prange's observation in this respect cannot be over-emphasized: "Technology, if employed at all, must be an integral component of the instructional *process* (my italics), not merely a sophisticated after-thought. --- Institutions must change their haphazard approach to instructional media and technology applications. Educational technology programs must be integrated with the overall institutional process."⁽²¹⁾ In the case of the UWC the main thrust behind the implementation of CBE was that it would be woven into the fabric of the curriculum and not only form an embellishment to the traditional teaching situation. This approach involves in turn intensive staff development. All this would hardly be possible if the new technology were looked upon as experimental.

In the case of the UWC the concept was propagated campus-wide. This resulted in divergent departments getting involved, so much so that within less than a month after the 16 terminals came into full operation, the hours of terminal availability had to be extended from five to eleven hours per day. Five months later the hours again had to be extended, this time to a total of 16 hours per day. Six months after installation 17 departments, ranging from New Testament Greek to Pharmacology, were already making use of instructional computing and were involving more than 1400 students per week.⁽²²⁾ (This was the maximum we could accommodate.) A study done during February 1982 showed that 93 per cent of the terminals were in use at any given hour between 08h30 to 16h30.

The initial ways of utilizing the system should be commented on. In a very depressing article entitled "The Myth of Educational Technology" (with the even more depressing page heading of "Is there Hope for the Future?")⁽²³⁾ Berkman sees the computer-managed instruction (CMI) facility of the system as "perhaps the only reality-centred undertaking the learning industry has so far attempted." Berkman also argues that CMI applies the computer's data-storage capacity to the management of each individual student's work on a subject-by-subject basis. Again I have to disagree. Management of the learning process concerns not only data storage, but also the more important tasks of diagnosing learning problems and referring students to remedial material. If the focus is on problem-solving, it stands to reason that computer-managed instruction and computer-assisted instruction go hand in hand. If what Berkman says is true, the potential of the computer is narrowed down to an administrative function.

While the true advantage of computer-based education lies within CMI - that is, in both the delivery and evaluation of personalized instruction - the management aspects of CMI are intricate and require training of the teacher-user. It is understandable that staff are wary of investing their time to learn how to use a facility whose educational values are *unproven on a personal basis*. The problem, in short, is to get the teacher to "approach" computerized instruction without erecting an intervening barrier of staff training. At UWC, this was done by arranging opportunities for groups of students to utilize existing courseware (apart from management controls). This provided partial release of both students and teachers from an overburdened instructional schedule. The teacher was given a "free" look at the system.

Cost-benefit vs Cost-effectiveness: The elusive component

Reference has been made to the financial investment the University was willing to make. This brings the question of cost benefit and cost-effectiveness to the fore.

In an undertaking of this nature, cost benefit specifies what ought to happen whereas cost-effectiveness assesses the results. In an educational setting it would be naive to expect a linear correlation between benefits and effectiveness. Benefits concern a specific item whereas effectiveness may cause a ripple throughout the structure, and yet be very hard to assess. One example will explain what seems to be a contradiction in terms. During the 12-week student boycott of 1980, students refused to attend any lectures, yet the PLATO laboratory was overcrowded. Cost beneficial? As it turned out, yes. But how cost-effective?

One can look at cost-effectiveness from two interrelated angles:

1. How much does instruction via the computer cost per hour, and
2. How much do the students actually learn.

I shall deal with the first question first. Taking only the present situation as remaining constant over the next few years, which is unrealistic, considering the number of departments which are in the process of becoming involved, instruction via the computer may cost the University even below R2 per hour per student. Although important, this kind of cost-effectiveness says very little in itself. It is the second question which lies at the crux of the matter.

Returning to the 1980 boycott, we have evidence of improved student performance. Chemistry students, for instance, showed an 11 per cent improvement in examination scores when compared to 1979 results. However, to my mind the question as to how much (more) the student has actually learned is an educationally unsound one. There seems to be a far greater range of variables which enter into the teaching-learning process than are represented by a single medium of instruction, for the simple reason that instructional procedures cannot be homogeneously and independently isolated.⁽²⁴⁾ What is needed is a multivariate research paradigm which is broad enough to include the full multiplicity and patterning of factors entering the teaching-learning configuration.⁽²⁵⁾

In the case of CBE especially, most of the studies produce the researcher's anathema: "No significant differences".⁽²⁶⁾ But this should not count against it. What is at stake is educational technology in its widest connotation, not just one educational resource. Furthermore, effectiveness studies mostly try to prove incremental improvements on an ad hoc basis, not accounting for the educational context lying somewhere between a jungle and an aseptic sanctuary.⁽²⁷⁾ In the case of the UWC, CBE has been responsible for an altogether new approach to the teaching process. It is not uncommon to hear a colleague express amazement at his old methods of teaching. This awareness should also be accounted for in terms of cost-effectiveness. But how?

Educational technology implemented to fulfil specific needs will ensure significant results. Formative evaluations at both cognitive and affective levels forecast that CBE will in the full sense of the word be cost-effective at the UWC.

Conclusion: a bird's-eye view

The following will give a cursory overview of our current CBE developments:

- * Departmental Survey: The Teaching Centre has begun the collection of descriptive data on the present and/or projected uses of computer-based education within each of the UWC departments.

The primary purposes of the study are to make the departments aware of the need to make a formal evaluation of their computer-based instructional applications and to assist them in planning relevant evaluation activities. Funds are available for supporting promising assessment projects.

In addition to the primary objective of encouraging research, the survey will be used to:

- * identify and plan new staff development activities,
- * project the need to expand the present computing facility,
- * make each department aware of the total instruction computing activity at UWC, and
- * lay the foundation for the formation of a campus-wide "users group".

Very close to one half of all our academic departments have by now made use of the facilities on the system.

- * Training: About one third of the teaching staff are at present being trained in either an introductory course on the instructional applications of the UWC facility or a course dealing specifically with computer-based learning management. These courses are presented on a cyclical basis. A course on programming is scheduled for the second half of the year.
- * Courseware development: The involvement with SASSC materials continues. Furthermore there is a growing involvement of teaching staff in departmental courseware development. The possibility of acquiring lesson drivers* will speed up this process enormously. Towards the end of this year the first locally produced courseware ought to be officially published in the PLATO Courseware Library. Ways are being established whereby teaching staff may be temporarily released to work full-time on PLATO courseware development. This will hopefully materialize at the beginning of the next term (August 1982).
- * Evaluation procedures: Documentation is at present being prepared on ways in which the traditional methods of testing and examination may be partly replaced by evaluation through PLATO Learning Management.
- * Specific projects: Various departments have projects in the pipeline. The Department of English has taken the lead with a definite proposal for a multi-purpose language evaluation and remediation programme. This project should be completed by the end of this month.
- * Outreach: The Teaching Centre has recently completed a five year outreach plan which commences in July. Three interrelated projects are involved: a Mathematics/Sciences Matriculation Outreach Project, an Instructional Computing Services Dissemination Project, and a Computer Evaluation/Improvement Project. Initially four PLATO learning centres are to be established in the Coloured and Black communities neighbouring the University. The outreach plan is aimed at university and high school students and undereducated adults alike.
- * Future Planning: A detailed projection of developmental needs up to 1990 has been prepared. The plan covers the issues of policy making, staff development, communication/reporting, outreach activities, courseware development, and UWC staff-support functions.

The very immediate future - and I am thinking in terms of three to five years - will tell just how successful this restructuring of our educational system has been.

We have no doubt about the ability and potential of the computerized educational technology available to us. If applied assiduously, and with circumspection, it can be an enormously powerful tool in the struggle to keep modern education abreast of the demands of the modern world. And yet, computer-based education is by no means a fait accompli, a finished article neatly parcelled and ready for use. It offers much as it stands, it promises much more. What we have to do, here in South Africa as well as elsewhere in the world, is to ensure that the human nature and human needs of our students are never forgotten - to ensure in fact that we do not make the mistake of creating a new ultra-sophisticated toy

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- * A lesson driver is a computer programme which permits the nonprogrammer to author computerized lessons. The instructor provides subject area knowledge: the lesson driver translates that content into computerized courseware.

for the amusement of an esoteric band of scientists at the expense of the students who are depending on us, the innovators, for a solution to their educational problems.

We, the educational designers, have the future of our students in our hands. It is a responsibility we cannot afford to shirk.

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(22)	<u>Course</u>	<u>Number of students</u>
	Applied Mathematics	81
	Biochemistry	49
	Biology	77
	Business Administration	30
	Chemistry	41
	Computer Science	9
	English	112
	German	260
	Greek	69
	Hebrew	107
	Latin	167
	Law	81
	Pharmacology	29
	Physics	209
	Social Work	89
	Sociology	30
	Statistics	30
		1470

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COMPUTER-ASSISTED LEARNING IN THE PRIMARY SCHOOL: NOW AND IN THE NEAR FUTURE

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ABSTRACT

The microcomputer and the primary school learner seem to be ideally suited to each other. Yet, development of C.A.L. in the primary school has been relatively sporadic and slow.

Of the reasons for the slow development of C.A.L. in the primary school, the lack of a pressing need for it must be the main one. However, there are areas in the primary school where C.A.L. is needed: simulations and enrichment for the gifted, drill and practice for the slow learners and remedial work and computer awareness for all. The few South African primary schools using C.A.L. are investigating these possibilities. There are however, many problems to overcome.

1. THE PRIMARY SCHOOL LEARNER AND THE COMPUTER; A SUITABLE MATCH?

1.1 THE LEARNER.

The primary school learner is generally a very unsophisticated learner. He loves routine; it gives him satisfaction and security. He is easily enamoured by sound effects and will exert himself for a rewarding "peep-peep" or merely to avoid a non-approving "bzz". He is usually very much taken up with technology and accepts the computer as a part of to-day's world; not something unusual or something to be feared, but something that will be with us for always, like cars and aeroplanes. Through his learning, reading and recreational preferences, the primary school pupil demonstrates a liking for repetitive, interactive routines; something in which many C.A.L. programmes specialize - whether by design or not.

1.2 THE COMPUTER.

It is not only its interactive ability which makes the micro-computer a good teaching aid. The computer is also endlessly patient even when asked to repeat something for the n th time. The modern micro-computer is a friendly machine to pupils. The names, Apple, Pet, Tandy, are themselves attractive to children. They know names like Atari and Texas Instruments from their "T.V. games" and "Speak and Spell". Even the sound effects and many of the games are familiar to them.

There is often a "deeper" relationship than mere familiarity. The computer often "remembers" the child's name, and addresses him by name. Not only that, but depending on the programme, the computer may also remember exactly where he ended off last week and what extra help he needed. Few teachers can match that.

The fact that the computer uses short sections of text, animated illustrations and a well-planned (?) step by step approach make it a friendly machine to the primary school learner. The level of work done in the primary school is such that responses from the computer can be quick. Even if a response is slow, an "I am thinking" message will usually keep the learner content.

The computer and the primary school learner are well suited to each other. Asked why he preferred doing work for the computer to working for his teacher, a boy replied: "The computer never gets mad at me when I do something wrong, and my teacher does not make music when I have it right!"

2 C.A.L. IN PRIMARY SCHOOLS NOW.

The dividing line between primary and secondary education varies widely from country to country and quite often even within a country. Most C.A.L. applications over the world are in secondary and tertiary education, but what is secondary education to some would be Std 4 and 5 to us in South Africa.

In many countries (e.g. some of the German states), it is thought undesirable to allow computers into the primary schools. In other countries there have been significant developments.

2.1 THE U.S.A.

One cannot give a state-of-the-art summary without giving credit to the pioneering done in the United States. In fact, one is tempted to regard the developments in the United States as the state of the art. There are many reasons for developments in the U.S.A. being ahead of the rest of the world; and for the very same reasons, the American model cannot be slavishly copied by other countries. That does not mean that we can afford to ignore the American experience. It has become fashionable in some circles to "knock" American software. We have found that most worthwhile software for the primary school originates in the U.S.A. Is there another body which applies such stringent control over the primary school software it approves as the Minnesota Educational Computing Consortium. (MECC)?

Apart from MECC software, several commercially marketed American programmes are at present being tested in South African Primary schools.

2.2 ALASKA.

One of the most promising developments in C.A.L. is taking place in the 50th state, Alaska.

Whereas most computer use in schools is born out of a desire to use computers, C.A.L. in Alaska has been born out of a need to solve a problem. Although C.A.L. is used mostly in the secondary classes in Alaska, it is interesting to investigate their system design and policy.

Alaska is a vast but sparsely populated area with many small communities isolated by snow for weeks at a time, and even in summer, accessible only by boat or aeroplane. Schools may have as few as 20 pupils, between the ages of 5 and 18. Teachers typically come from a different culture, and are likely to remain at a school only for a year or two.

To ensure adequate teaching and a reasonable range of subject choices, the authorities commissioned the development of self-contained courses which combine the micro-computer, audio-tapes and printed material. The computers are used for drill and practice, tutorials, simulations and course management. For 1981/82 the system will be used by 80 communities.

Concerning management practices, the Alaskans caution:

"Do not permit the situation to develop where computer software developers are geographically isolated from your instructional designer".

and

"Do not let the technology become the purpose of the project. That is, educational goals should be the primary focus". 3)

Something to keep in mind.

2.3 ENGLAND.

Most C.A.L. applications are in secondary and tertiary education. Relatively little has been done in the primary school. In April 1980 there were 22 micro-computers in 33 primary schools in England. (In one case fourteen schools shared one micro-computer). Most of these were models with limited RAM and graphic ability. Schools had little software available, and what was available was often self-produced.

Since then, there have been tremendous developments in the United Kingdom, under the guidance of MEP (the Micro-electronics in Education Project) and the CET (the Council for Educational Technology.) Little of this has benefited C.A.L. in the primary school directly. Primary school teachers have, however, formed their own organisation, MAPE (Micro-electronic Applications in Primary Education). MAPE fulfils the function for primary schools that MUSE fulfils for secondary schools.

A most interesting development in the U.K. is the availability of a programme bank for micro-computers (Telesoftware) which is directly accessible by telephone line (Prestel). By the end of 1982 some 25 schools will have immediate access to a library of 100 programmes. (2)

2.4 TASMANIA

Some very worthwhile work is going on in Australian primary schools, especially in Tasmania. At present Tasmania already has more than ten years experience with computers in education. Tasmania introduced computer studies as a school subject as early as 1972. All secondary schools and many primary schools are connected to Tasnet, an educational computing network. In addition to this, many primary schools have micro-computers; either their own, or on loan from the education department.

The most interesting aspect of the use of computers in education in Tasmania is the use of LOGO, both as an element in their computer awareness course for primary schools and as a first programming language in their computer course for high school pupils. LOGO is the language developed by Seymour Papert at the Massachusetts Institute of Technology for Texas Instruments. For primary school pupils the stress is placed virtually totally on the turtle graphics aspect of LOGO. The Tasmanian approach to computer use in the primary school seems to be influenced strongly by Papert's book "Mindstorms". (3)

2.5 SOUTH AFRICA

A fair number of high schools in South Africa have computers, mostly for computer studies and administration, a few of them for C.A.L. At present, to the best of my knowledge, only two primary schools in South Africa use C.A.L.: Saxonwold Primary in the Transvaal and Sea Point Boys' Primary in the Cape. Saxonwold has a TRS 80 on loan, while Sea Point Boys' Primary has two Apples of its own. Judging by the response received by the Schools Computers in Education Group (SCEG) there should be more primary schools with C.A.L. shortly. Of the 168 members on the SCEG mailing list at the end of March 1982, no less than 20 were from Primary Schools.

As the author is familiar with Sea Point Boys' Primary School he will often refer to experiences at the school.

3. WHY NOT MORE WIDESPREAD?

3.1 NO NEED

C.A.L. is not more widespread in primary schools because there is no clearly and generally perceived need for it. It is as simple and as basic as that.

There is no problem in the primary school which, by common agreement at this stage, could not be solved without the application of computer technology. This is not to say that computers cannot successfully be used in

the primary school, it is only that those who see the possibilities are at present a very small minority.

3.2 TEACHERS.

At present most countries which have the ability to introduce computers into education, have an oversupply of primary school teachers. Even in South African schools there is no shortage of teachers for Stds 2 to 5.

In these countries too, the selection and training of teachers usually encourages technically minded candidates to train for secondary education. Teachers in these countries are often conservative in outlook and there is considerable resistance to change.

With no clearly perceived need, and with only a very limited number of teachers familiar with computers, it is extremely difficult to build up a ground-level staff-desire to use computers. The computer is therefore seen as being imposed from above.

One school reported a negative attitude from most members, despite enthusiasm from the principal and very positive encouragement from the school committee. The computer was put in the staff room for a few weeks and made available to staff members over week-ends. Several staff members became Space Invader addicts and when the computers were eventually put to serious work they were both fully booked 5 days a week for the rest of the term. As the novelty wore off though, bookings also dropped, until the computers were used only for a few hours per week.

The problem is being solved by more explicit demonstrations of software and a listing of programmes available, giving details such as:

- 1) What will the learner be able to do after completing the programme?
- 2) What instructions must the learner be given before he is sent to the computer room?
- 3) What will the learner bring back to the classroom?

This has led to staff members making more use of the computers to solve what they see as real educational problems. In addition the implementation of a remedial spelling programme may convince staff members of the potential value of the computer.

3.3 BUDGETS

While some may be convinced that the computer can be a useful aid in education, they do not necessarily agree that it is financially viable. This is a common problem. Perhaps we are so blinded by our year-by-year method of budgeting, that we cannot see how cheap a micro-computer is over a life span of say, five years.

3.4 SOFTWARE

Most of the software available is of American origin. This is unacceptable to many teachers because of the spelling ("catalog") and other conventions (52-19). Tailormade software to fit our needs and taste, however, will be extremely expensive. A programme to run the administration of a primary school, for example, may cost R2500 or more. The likelihood that we shall

develop our own good software in the near future is not great. Most good teachers are not programmers, and most good programmers are not teachers.

Another problem which affects especially primary school learners, is the inconsistent presentation of software programmes. Often there are no clear instructions on the screen and primary school learners are not good at reading instruction manuals. This means that the teacher or librarian has to be called to show what must be done next, resulting in the unnecessary use of expensive teachers' time.

If computers are to be an economically viable teaching aid, they will have to rely as little as possible on continued teacher intervention for mere technical reasons.

4. C.A.L. IN THE IMMEDIATE FUTURE.

There is no doubt that computers can fulfil a useful function in the school administration. We are sure to see the introduction of micro-computers or terminals in an increasing number of schools over the next few years. For the teacher, however, the computer will be a help in the areas where he does not have the time or the patience to do the work himself. One of these areas is the analyses of test and examination marks; others would be Computer Assisted Learning for individual pupils where needs differ from those of the group.

4.1 THE SLOW LEARNER.

The patience of the computer, the repetitive nature of many C.A.L. programmes and the slow learner, form an ideal combination. Slow learners have a long history of failing to interact successfully with human teachers. A few of them respond well to interacting with the computer. Although it is still too early to draw any firm conclusions, we suspect that the confidence they gain in front of the computer makes it easier for them to respond to their teacher afterwards. I am not aware of any research project being carried out in South Africa at present, to measure the gains made by slow learners as a result of C.A.L., but valuable work is carried out elsewhere, e.g. programmes for Maths in Israel and handwriting in Australia.

4.2 THE REMEDIAL LEARNER.

Another learner who has failed to respond to human interaction is the remedial learner. By remedial learner we mean a learner who shows a weakness in one aspect of his school work, but performs normally or better in the rest of his work.

Sea Point Boys' Primary School is at present busy with a remedial programme in spelling. During the first three years of schooling, spelling is taught virtually exclusively through the phonic method. This has resulted in most pupils being well above the national average in spelling, but a number of boys of normal or above normal intellectual ability have below average spelling ability. For those they have started a remedial programme relying entirely on the visual image and sequencing of letters enforced by the computer.

Each pupil on the remedial programme learns and revises ten spelling words a day. In order to bring the words to the pupil in context, the words are

presented in sentences. There are at present 75 lessons of 10 sentences, for each of the standards 2,3,4 and 5. The computer monitors the progress of every pupil and repeats the last eleven words spelt wrong for each pupil after every lesson. The pupil takes a print-out back to his teacher who checks the list of words to see if there is any pattern in the words that would indicate the necessity to revise certain spelling rules. The computer also supplies a print-out giving the principal a weekly summary of the progress made by the pupils, so that he can check if each pupil has completed the required number of lessons.

The remedial programme is well controlled. The remedial group and a control group of pupils in the same classes were tested for spelling ability before the programme started. Both groups will receive the same tuition during the run of the programme with the exception of the remedial spelling. At the end of the year, both groups will be tested again, using an equivalent test.

There is little doubt in our minds that there will be a significant improvement, but we are not sure that this improvement will be significant enough to make the application of C.A.L. economically justifiable. We find that, at least now at the beginning of the programme, it still takes a lot of teacher intervention to get the C.A.L. moving smoothly.

One unexpected, and unfortunately unmonitored side effect is that the teachers of the younger pupils involved, claim an improvement in reading even at this early stage.

4.3 THE FAST LEARNER.

The very fact that most software programmes available are not covering our syllabi, makes them attractive to use as enrichment for the faster learners. We find that the fast learners take to the computer well. The computer allows them to progress at their speed and gives them virtually immediate replies. They especially like the simulations, be they of the food chain in "Odell Lake" or of running an ancient kingdom in "Hamurabi". A rather unexpected development was the great interest shown by these pupils in learning to programme the computer themselves.

4.4 SIMULATIONS.

One of the problems of the maths teacher is that there is little carry-over from what he teaches. Pupils get little opportunity to apply the maths they have mastered in their daily lives. The teacher could create situations where the pupils use their knowledge. e.g. let the Std 5 class run the tuck-shop. This has some obvious disadvantages.

Running simulations on the computer seems to be a most acceptable compromise. Simulations on the computer have some distinct advantages:

- 1) Re-action is immediate - there is no need to wait for outcomes.
- 2) Mistakes do not lead to bankruptcy or explosions.
- 3) They can take place within the classroom.
- 4) The problem can be simplified.
- 5) Complications can be introduced one by one.

4.5 PROGRAMMING

What we have been discussing up to now is what Seymour Papert calls "using computers to programme children". Children from the age of ten and

upwards seem to take programming quicker than their teachers. We ran an experimental computer club during the school holidays and found that we could not get the pupils to leave the school premises. Even now, pupils who left the school months ago, regularly return because the high-school computer is fully booked.

Our pupils have been programming in basic, but we are eager to experiment with LOGO as soon as it becomes available for the Apple.

Early results obtained in Tasmania (5) seem to indicate that programming experience leads to a better ability to solve problems.

5. PROBLEMS:

5.1 PROGRAMMING.

Unlike their pupils most teachers do not take to programming easily. We were disappointed when only 20% of our staff took up our offer of a free introduction to BASIC, but this percentage is higher than the approx. 14% reported by Ron Jones in the United Kingdom. (6)

We are now having a close look at PILOT to write our courseware. The language certainly solves a number of our problems, but has some distinct disadvantages too:

- 1) Animation is difficult.
- 2) Graphics and sound sequences must be assessed from disc. This causes annoying delays.
- 3) A large quantity of disc storage is required.
- 4) The system is very hard on discs and disc drives.

So far, other author languages such as PASS have been out of our reach financially.

5.2 TIME.

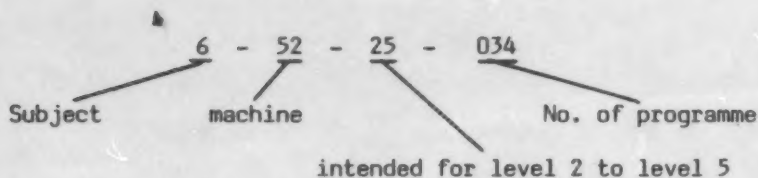
With a limited number of keyboards available it becomes difficult to co-ordinate computer time so that it does not clash with other classroom activities. The normal primary school time-table does not leave much opportunity for individual pupils to leave the room for up to 30 minutes at a time to do remedial or enrichment programme on the computer.

5.3 TYPING.

We are very aware of the fact that we are teaching children wrong typing habits, but have not found a practical solution to this problem.

5.4 CATALOG

We have up to now used the Dewey system as for library books and see no reason for changing to anything else. This arrangement allows us to integrate our catalogues for all our resources; audio-visual and printed material, using a different prefix for each. We are aware that MUSE has found it necessary to introduce a cataloging system indicating the academic level of the user as well as the kind of machine for which the programme is intended: e.g.



We would prefer retaining the Dewey system and putting additional information on the catalogue card.

Perhaps we shall have direct access to a software bank by telephone line or TV channel, in the not too distant future. We shall then be able to order from the menu and sit back.

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